FIG.1

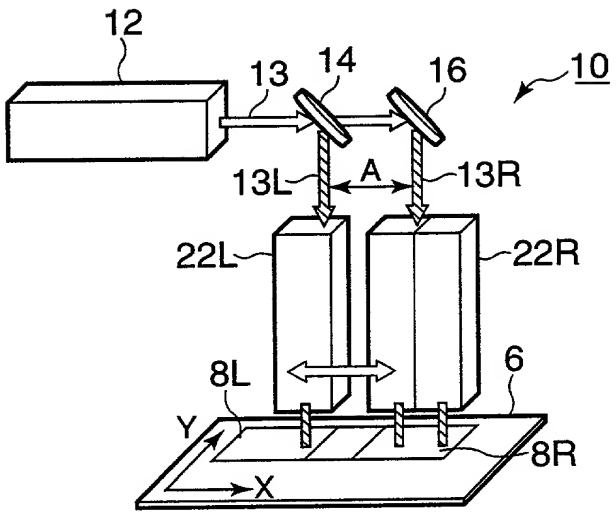

12
13
14
16
10
13L
A
13R
22L
22R
8L
6
Y
8R
X

FIG.2

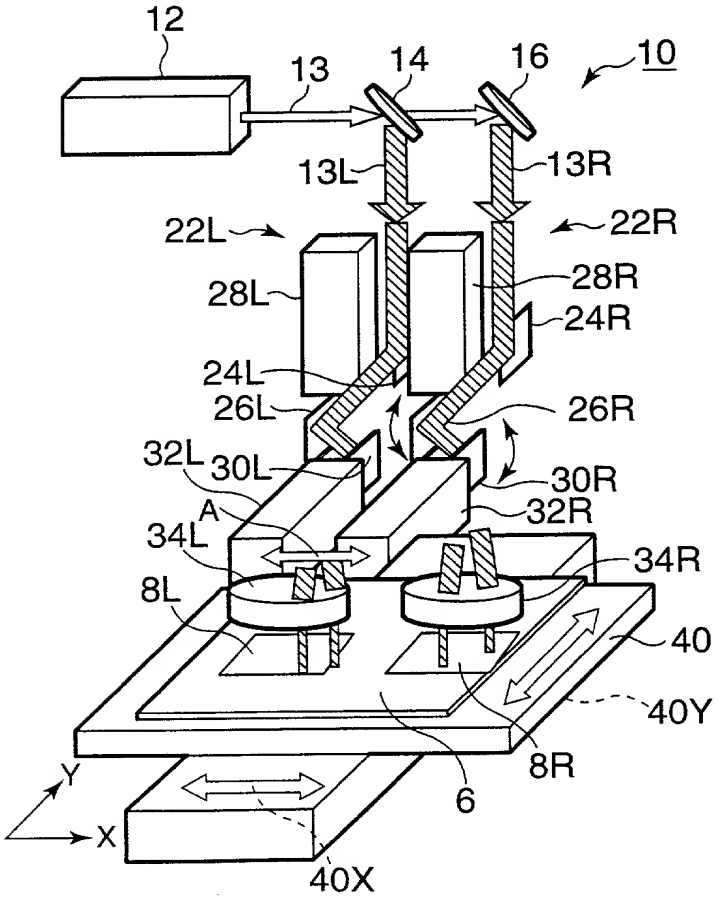

12
13
14
16
10
13L
13R
22L
22R
28L
28R
24R
24L
26L
26R
32L
30L
30R
A
32R
34L
34R
8L
40
40Y
8R
Y
6
X
40X

FIG.3

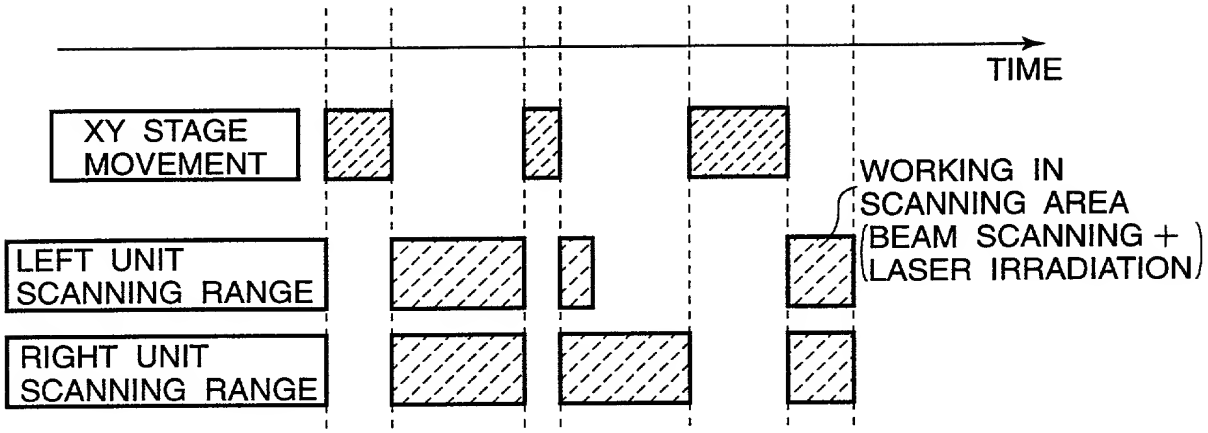

TIME
XY STAGE MOVEMENT
WORKING IN SCANNING AREA (BEAM SCANNING + LASER IRRADIATION)
LEFT UNIT SCANNING RANGE
RIGHT UNIT SCANNING RANGE

FIG.4

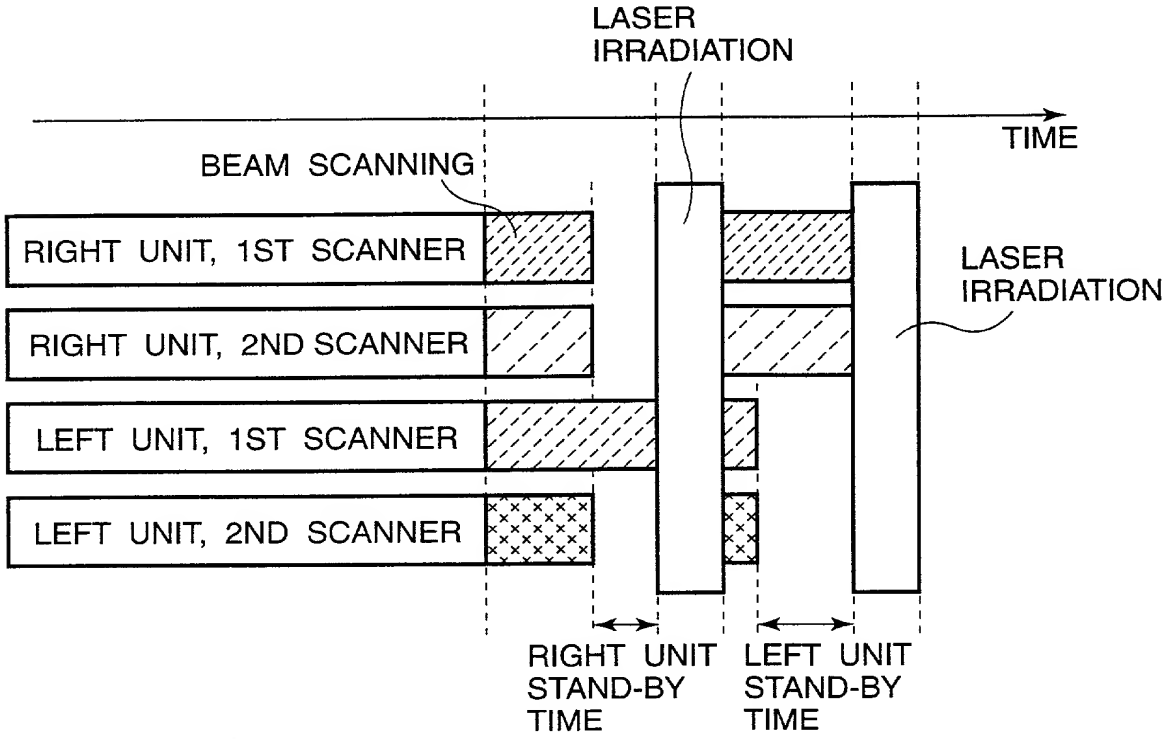

LASER IRRADIATION
TIME
BEAM SCANNING
RIGHT UNIT, 1ST SCANNER
RIGHT UNIT, 2ND SCANNER
LEFT UNIT, 1ST SCANNER
LEFT UNIT, 2ND SCANNER
LASER IRRADIATION
RIGHT UNIT STAND-BY TIME
LEFT UNIT STAND-BY TIME

FIG.5

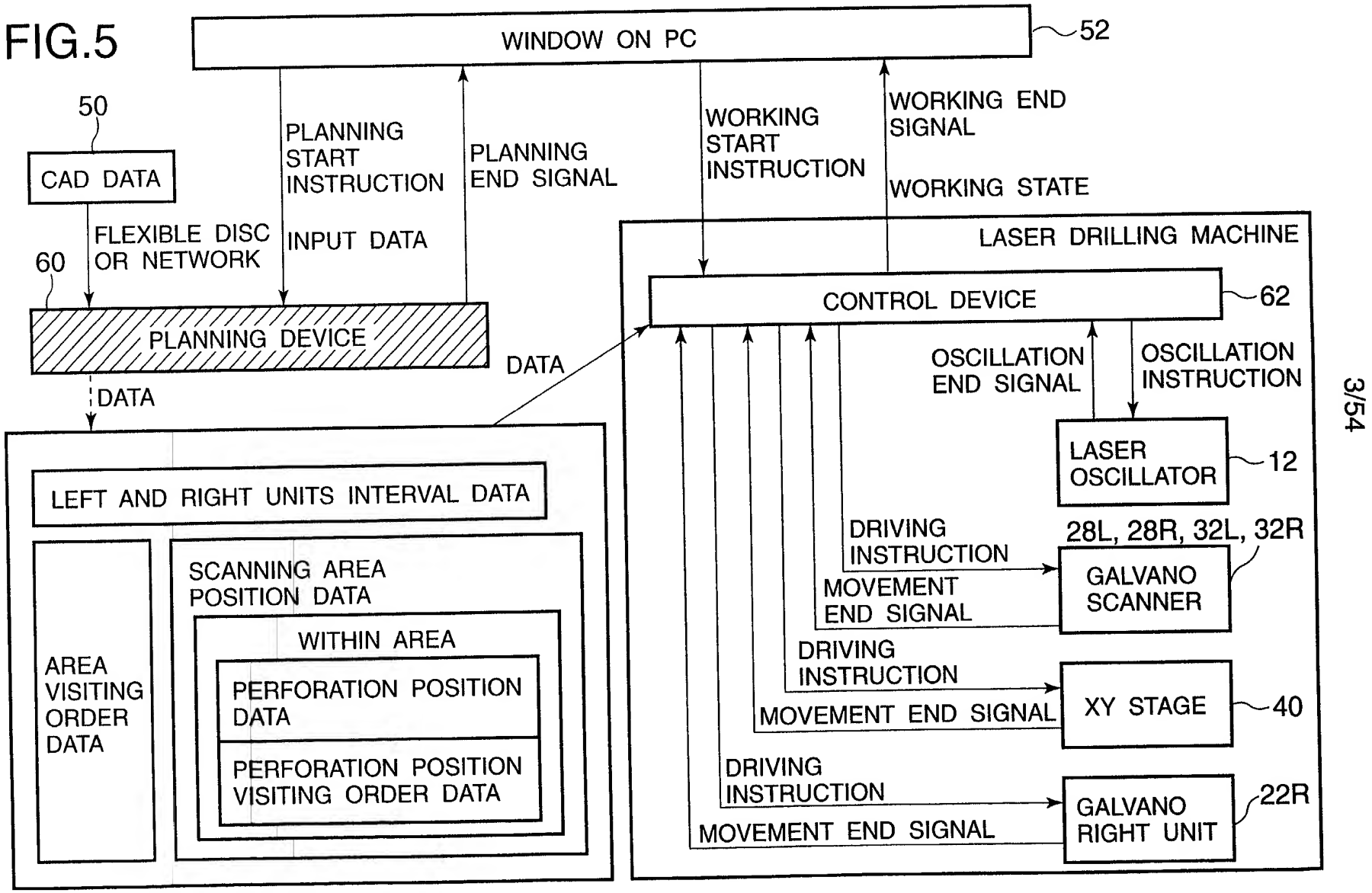

WINDOW ON PC
52
50
CAD DATA
PLANNING START INSTRUCTION
PLANNING END SIGNAL
WORKING START INSTRUCTION
WORKING END SIGNAL
WORKING STATE
FLEXIBLE DISC OR NETWORK
INPUT DATA
60
PLANNING DEVICE
DATA
DATA
LASER DRILLING MACHINE
CONTROL DEVICE
62
OSCILLATION END SIGNAL
OSCILLATION INSTRUCTION
LASER OSCILLATOR
12
LEFT AND RIGHT UNITS INTERVAL DATA
AREA VISITING ORDER DATA
SCANNING AREA POSITION DATA
WITHIN AREA
PERFORATION POSITION DATA
PERFORATION POSITION VISITING ORDER DATA
DRIVING INSTRUCTION
28L, 28R, 32L, 32R
MOVEMENT END SIGNAL
GALVANO SCANNER
DRIVING INSTRUCTION
MOVEMENT END SIGNAL
XY STAGE
40
DRIVING INSTRUCTION
MOVEMENT END SIGNAL
GALVANO RIGHT UNIT
22R

FIG.6

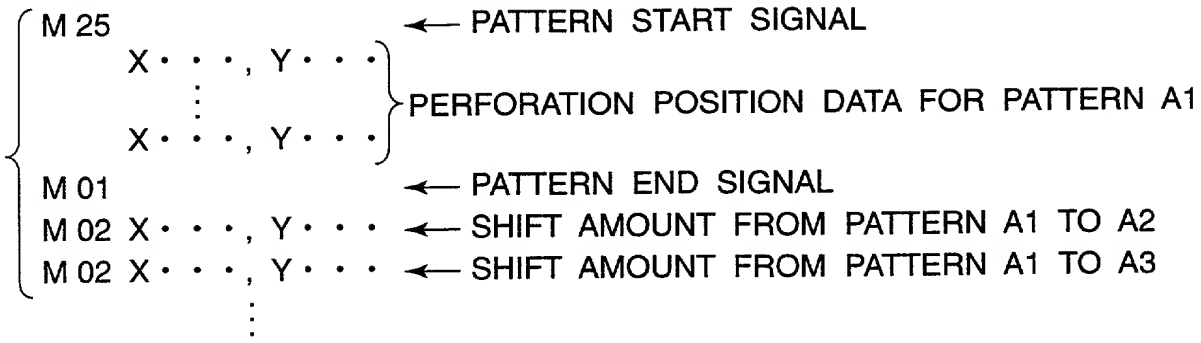

M 25
X・・・, Y・・・
X・・・, Y・・・
PERFORATION POSITION DATA FOR PATTERN A1
PATTERN START SIGNAL
M 01
PATTERN END SIGNAL
M 02 X・・・, Y・・・
SHIFT AMOUNT FROM PATTERN A1 TO A2
M 02 X・・・, Y・・・
SHIFT AMOUNT FROM PATTERN A1 TO A3

FIG.7

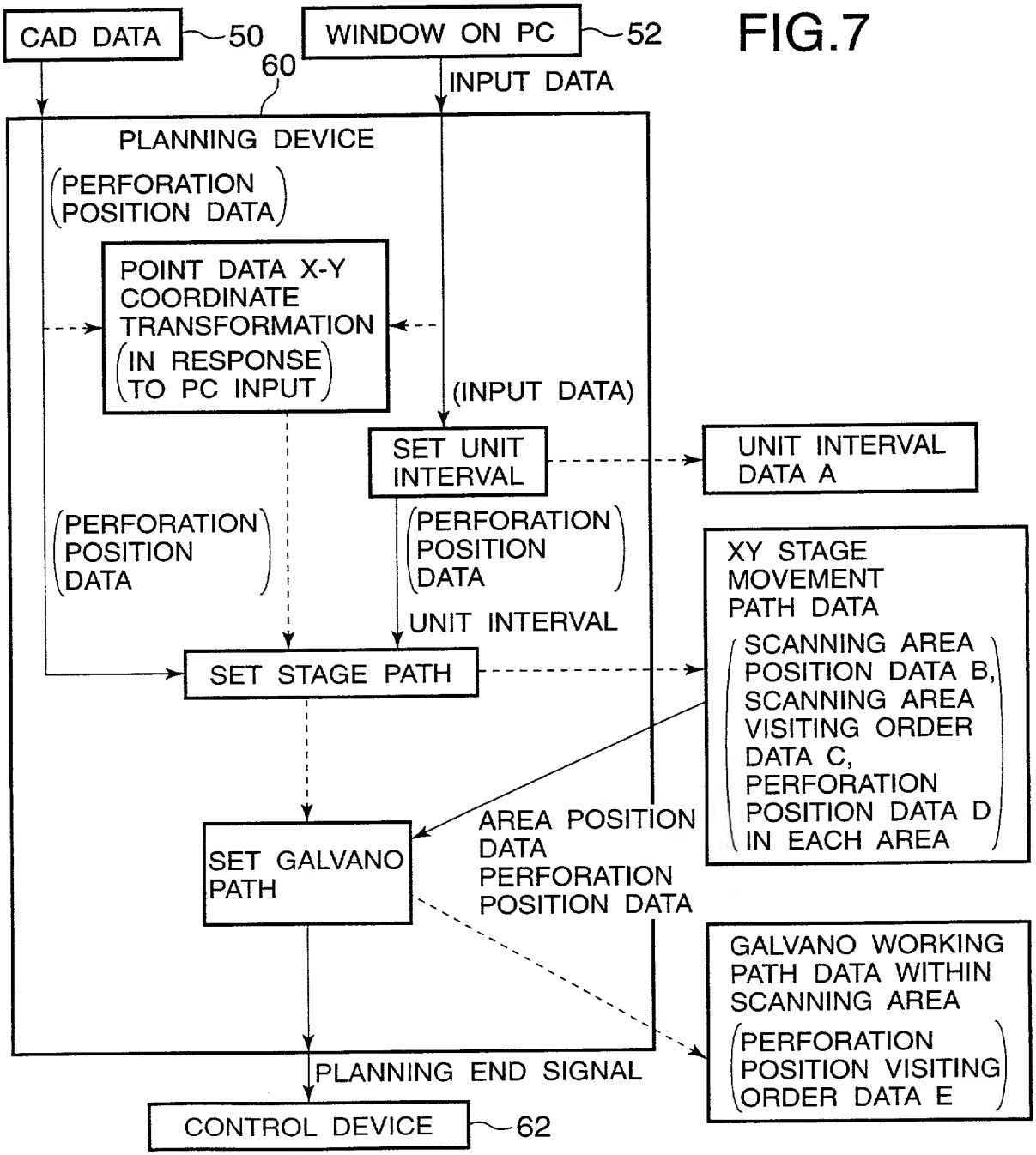

CAD DATA
50
WINDOW ON PC
52
60
INPUT DATA
PLANNING DEVICE
(PERFORATION POSITION DATA)
POINT DATA X-Y COORDINATE TRANSFORMATION (IN RESPONSE TO PC INPUT)
(INPUT DATA)
SET UNIT INTERVAL
UNIT INTERVAL DATA A
(PERFORATION POSITION DATA)
(PERFORATION POSITION DATA)
UNIT INTERVAL
XY STAGE MOVEMENT PATH DATA (SCANNING AREA POSITION DATA B, SCANNING AREA VISITING ORDER DATA C, PERFORATION POSITION DATA D IN EACH AREA)
SET STAGE PATH
SET GALVANO PATH
AREA POSITION DATA PERFORATION POSITION DATA
GALVANO WORKING PATH DATA WITHIN SCANNING AREA (PERFORATION POSITION VISITING ORDER DATA E)
PLANNING END SIGNAL
CONTROL DEVICE
62

FIG.8

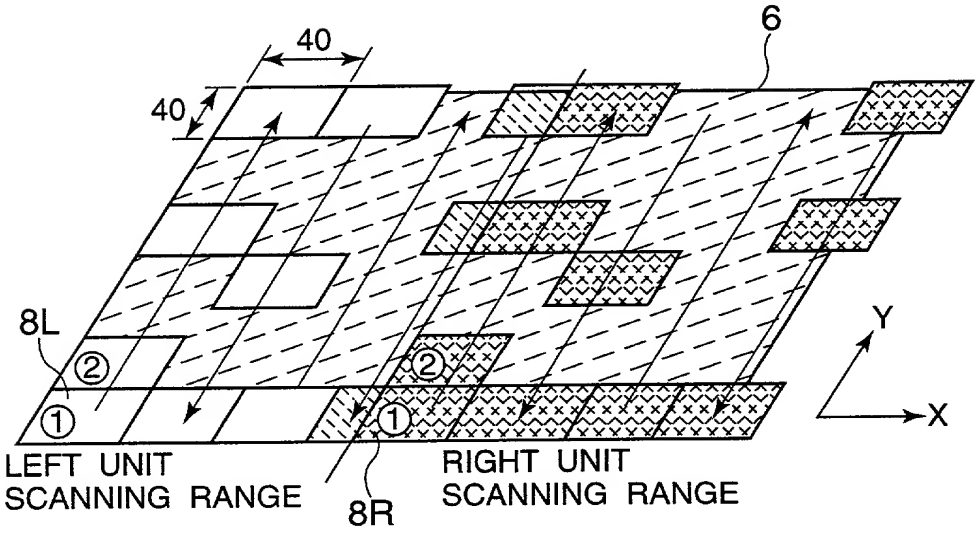

40
40
6
8L
②
①
②
①
Y
X
LEFT UNIT
SCANNING RANGE
8R
RIGHT UNIT
SCANNING RANGE

FIG.9

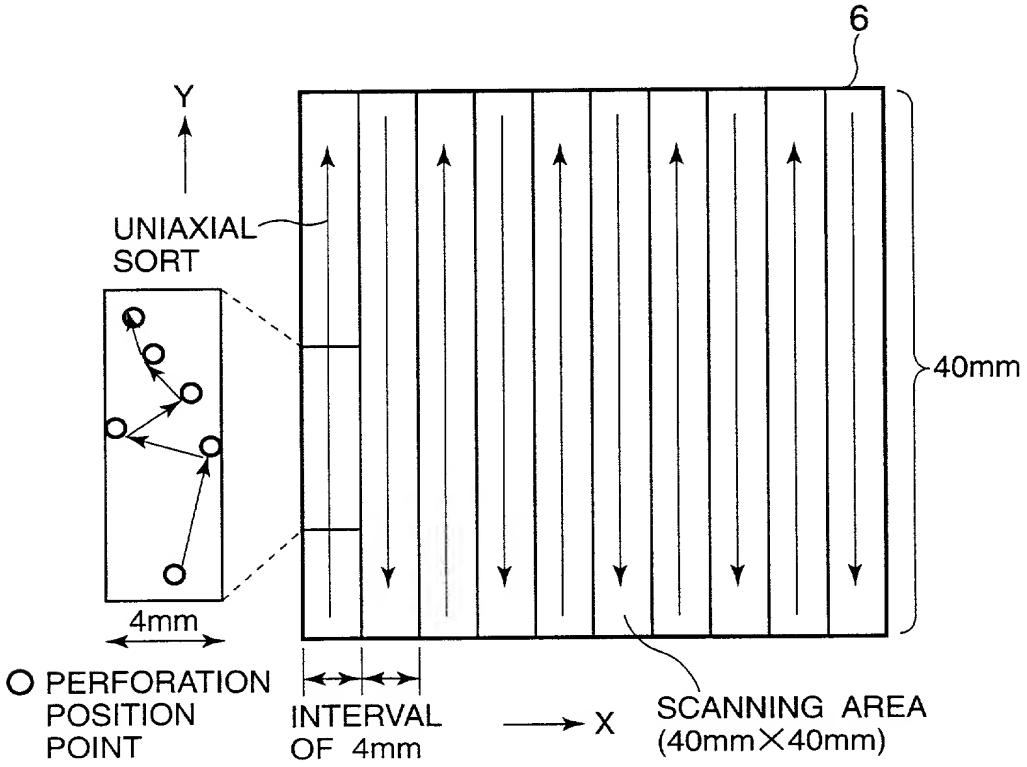

6
Y
UNIAXIAL
SORT
40mm
4mm
O PERFORATION
POSITION
POINT
INTERVAL
OF 4mm
X
SCANNING AREA
(40mm×40mm)

FIG.10

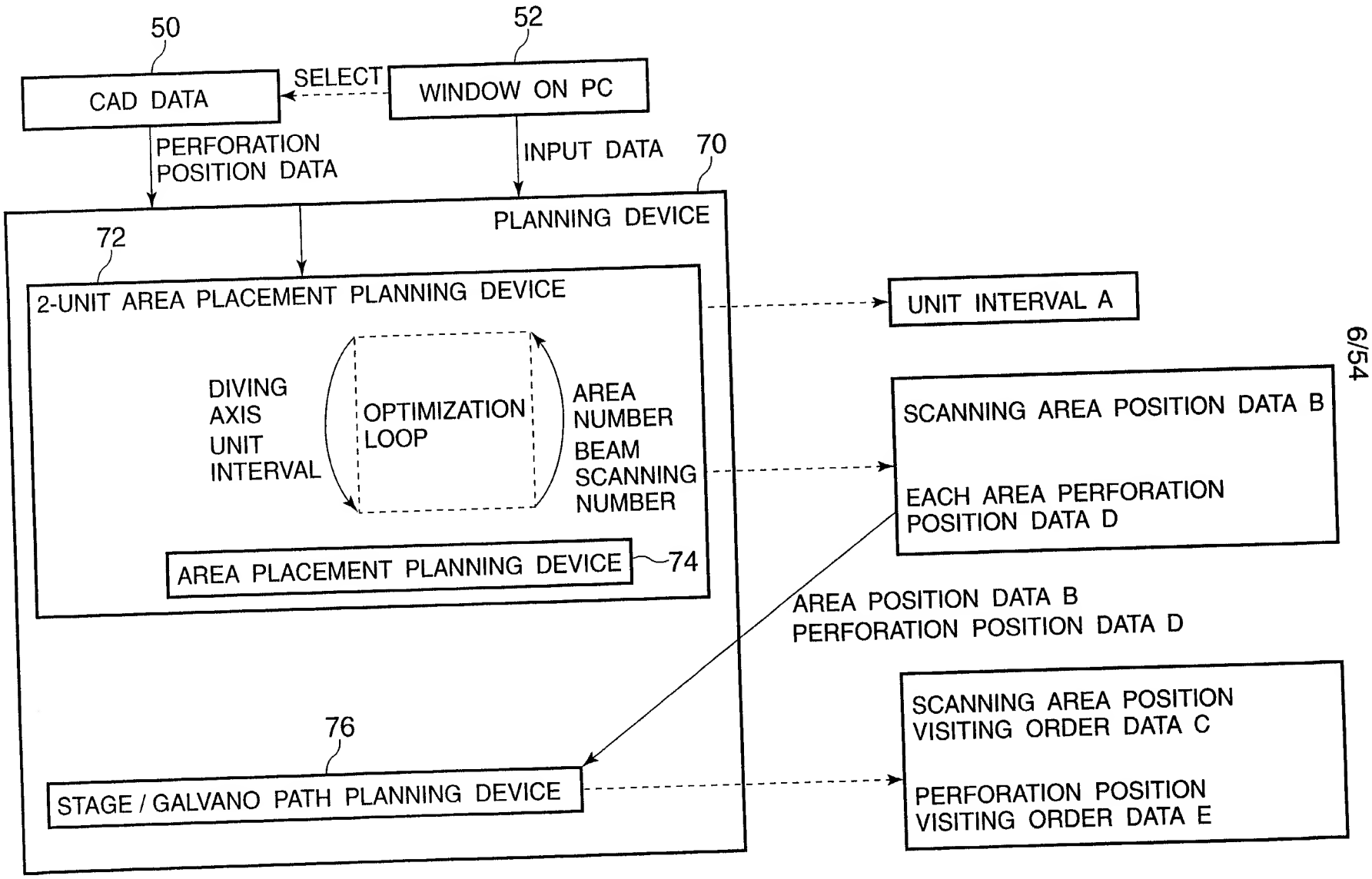

50
52
CAD DATA
SELECT
WINDOW ON PC
PERFORATION POSITION DATA
INPUT DATA
70
PLANNING DEVICE
72
2-UNIT AREA PLACEMENT PLANNING DEVICE
UNIT INTERVAL A
DIVING AXIS UNIT INTERVAL
OPTIMIZATION LOOP
AREA NUMBER
BEAM SCANNING NUMBER
SCANNING AREA POSITION DATA B
EACH AREA PERFORATION POSITION DATA D
AREA PLACEMENT PLANNING DEVICE
74
AREA POSITION DATA B
PERFORATION POSITION DATA D
76
SCANNING AREA POSITION VISITING ORDER DATA C
STAGE / GALVANO PATH PLANNING DEVICE
PERFORATION POSITION VISITING ORDER DATA E

FIG.12

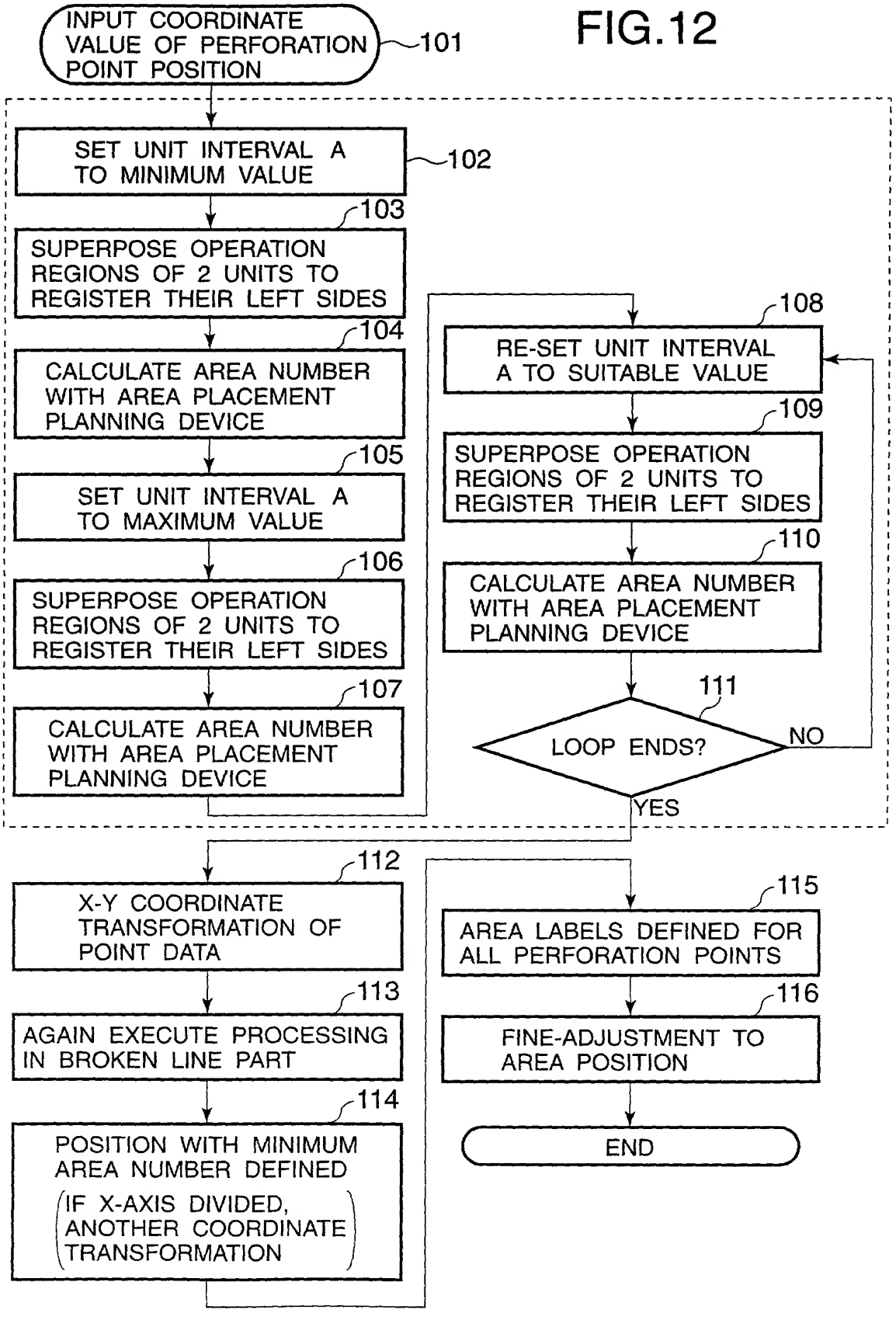

INPUT COORDINATE VALUE OF PERFORATION POINT POSITION
101
SET UNIT INTERVAL A TO MINIMUM VALUE
102
103
SUPERPOSE OPERATION REGIONS OF 2 UNITS TO REGISTER THEIR LEFT SIDES
104
CALCULATE AREA NUMBER WITH AREA PLACEMENT PLANNING DEVICE
105
SET UNIT INTERVAL A TO MAXIMUM VALUE
106
SUPERPOSE OPERATION REGIONS OF 2 UNITS TO REGISTER THEIR LEFT SIDES
107
CALCULATE AREA NUMBER WITH AREA PLACEMENT PLANNING DEVICE
108
RE-SET UNIT INTERVAL A TO SUITABLE VALUE
109
SUPERPOSE OPERATION REGIONS OF 2 UNITS TO REGISTER THEIR LEFT SIDES
110
CALCULATE AREA NUMBER WITH AREA PLACEMENT PLANNING DEVICE
111
LOOP ENDS?
NO
YES
112
X-Y COORDINATE TRANSFORMATION OF POINT DATA
113
AGAIN EXECUTE PROCESSING IN BROKEN LINE PART
114
POSITION WITH MINIMUM AREA NUMBER DEFINED
(IF X-AXIS DIVIDED, ANOTHER COORDINATE TRANSFORMATION
115
AREA LABELS DEFINED FOR ALL PERFORATION POINTS
116
FINE-ADJUSTMENT TO AREA POSITION
END

FIG.13

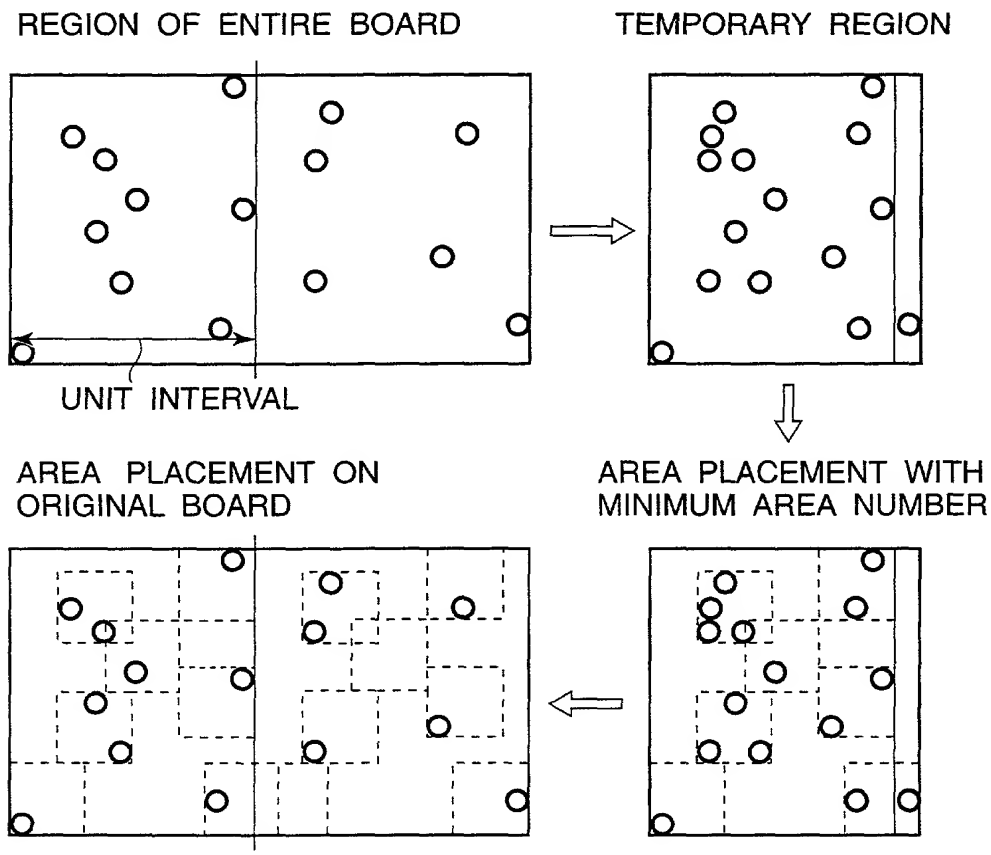

REGION OF ENTIRE BOARD
TEMPORARY REGION
UNIT INTERVAL
AREA PLACEMENT ON ORIGINAL BOARD
AREA PLACEMENT WITH MINIMUM AREA NUMBER

FIG.14

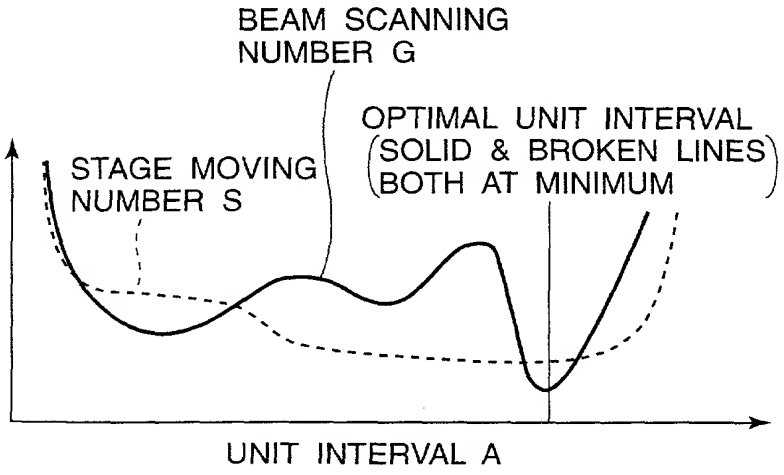

BEAM SCANNING NUMBER G
OPTIMAL UNIT INTERVAL (SOLID & BROKEN LINES BOTH AT MINIMUM
STAGE MOVING NUMBER S
UNIT INTERVAL A

FIG.15

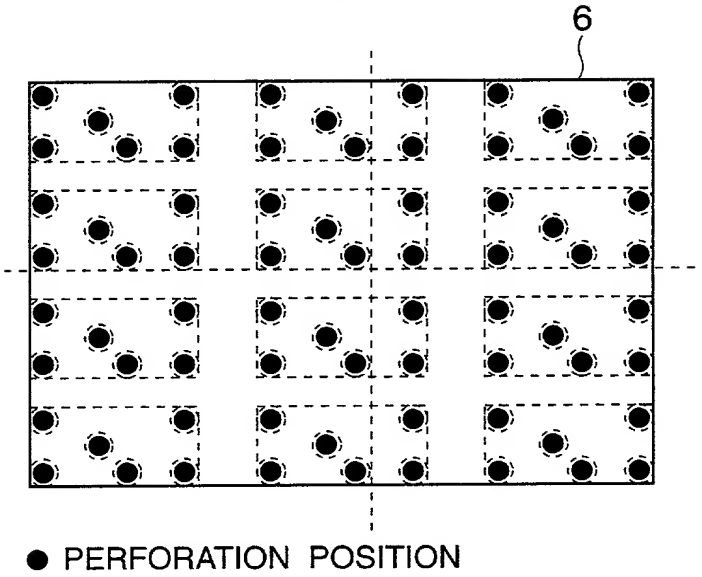

6
● PERFORATION POSITION

FIG.16

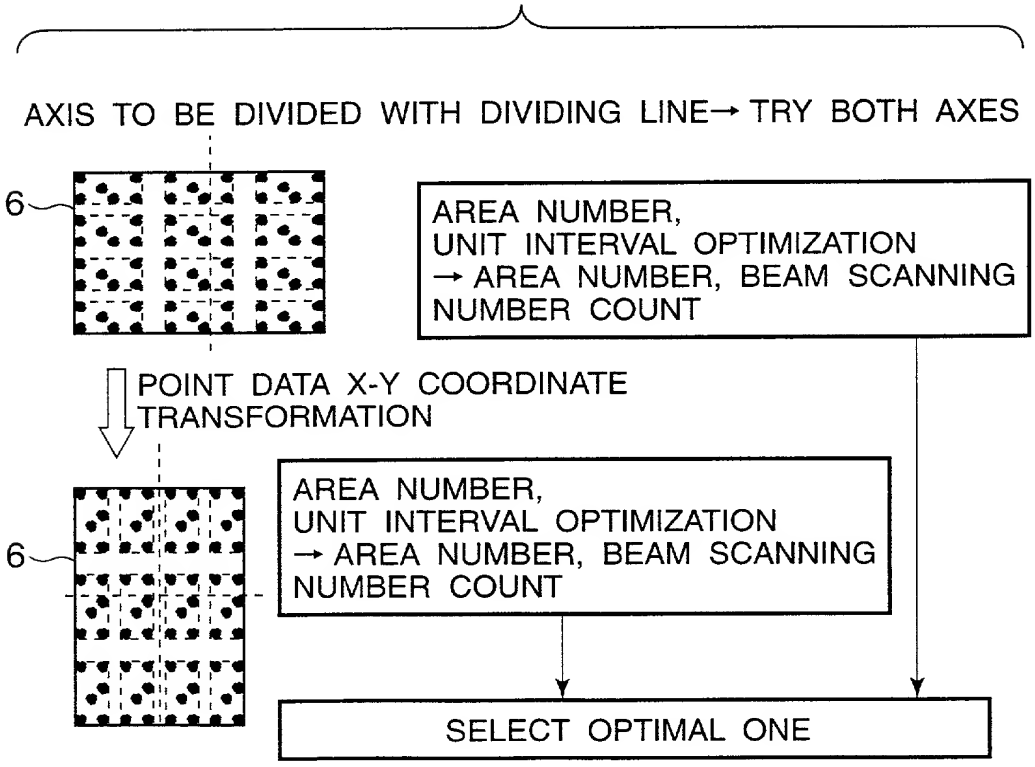

AXIS TO BE DIVIDED WITH DIVIDING LINE→ TRY BOTH AXES
6
AREA NUMBER,
UNIT INTERVAL OPTIMIZATION
→ AREA NUMBER, BEAM SCANNING
NUMBER COUNT
POINT DATA X-Y COORDINATE
TRANSFORMATION
6
AREA NUMBER,
UNIT INTERVAL OPTIMIZATION
→ AREA NUMBER, BEAM SCANNING
NUMBER COUNT
SELECT OPTIMAL ONE

FIG.17

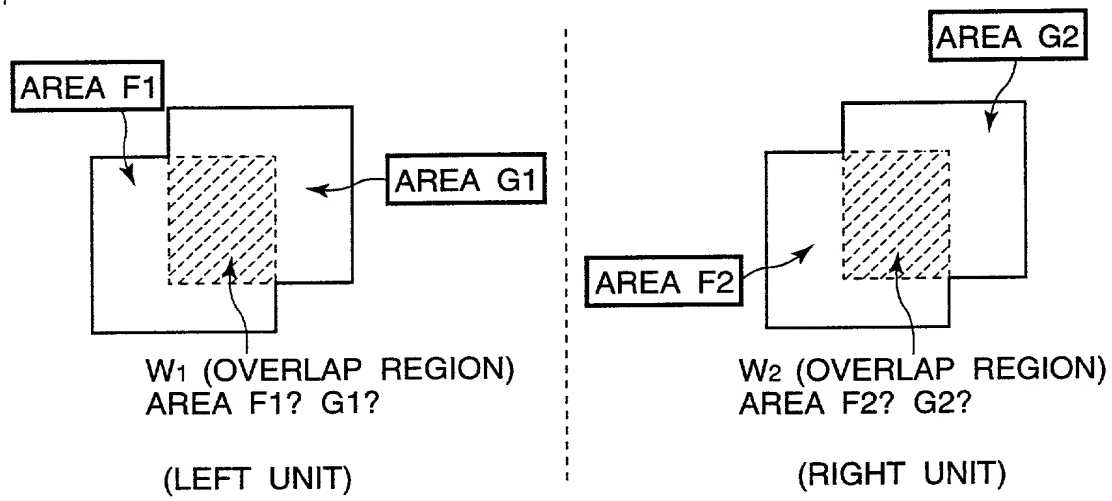

AREA F1
AREA G1
W1 (OVERLAP REGION)
AREA F1? G1?
(LEFT UNIT)
AREA G2
AREA F2
W2 (OVERLAP REGION)
AREA F2? G2?
(RIGHT UNIT)

FIG.18

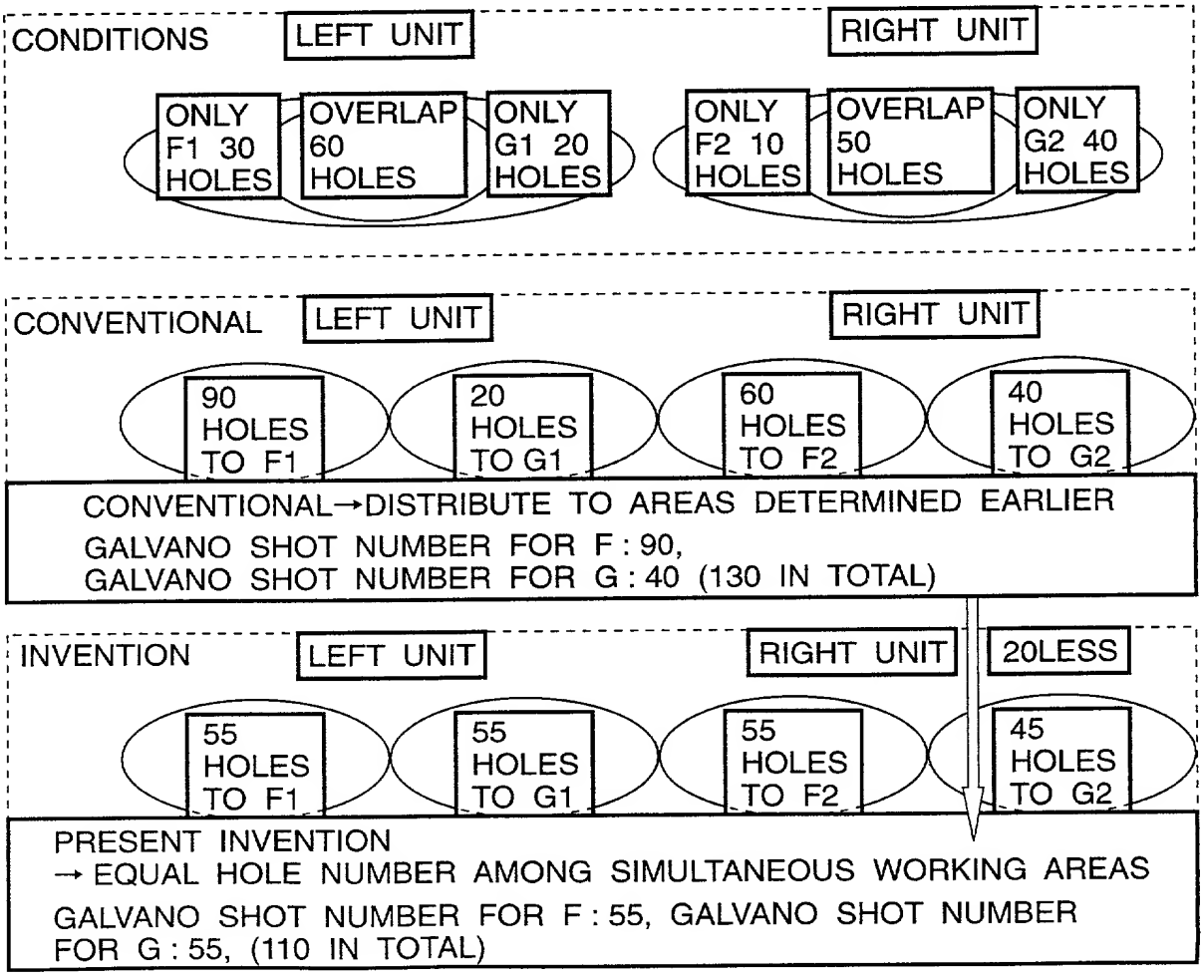
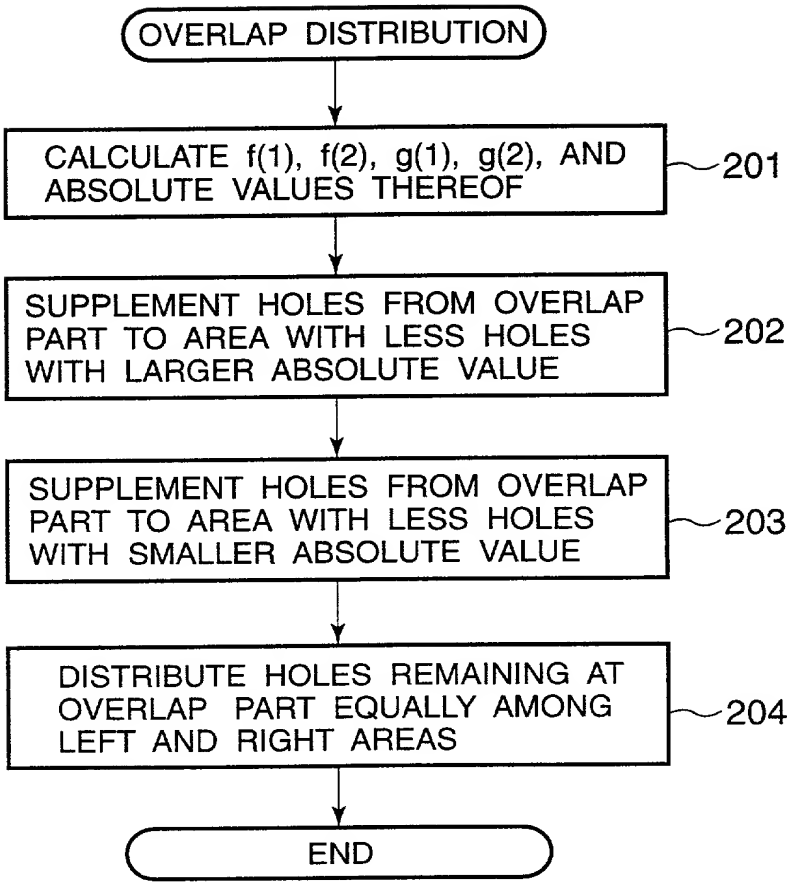

CONDITIONS
LEFT UNIT
RIGHT UNIT
ONLY F1 30 HOLES
OVERLAP 60 HOLES
ONLY G1 20 HOLES
ONLY F2 10 HOLES
OVERLAP 50 HOLES
ONLY G2 40 HOLES
CONVENTIONAL
LEFT UNIT
RIGHT UNIT
90 HOLES TO F1
20 HOLES TO G1
60 HOLES TO F2
40 HOLES TO G2
CONVENTIONAL→DISTRIBUTE TO AREAS DETERMINED EARLIER
GALVANO SHOT NUMBER FOR F : 90,
GALVANO SHOT NUMBER FOR G : 40 (130 IN TOTAL)
INVENTION
LEFT UNIT
RIGHT UNIT
20LESS
55 HOLES TO F1
55 HOLES TO G1
55 HOLES TO F2
45 HOLES TO G2
PRESENT INVENTION
→ EQUAL HOLE NUMBER AMONG SIMULTANEOUS WORKING AREAS
GALVANO SHOT NUMBER FOR F : 55, GALVANO SHOT NUMBER FOR G : 55, (110 IN TOTAL)

FIG.19


OVERLAP DISTRIBUTION
CALCULATE f(1), f(2), g(1), g(2), AND ABSOLUTE VALUES THEREOF
201
SUPPLEMENT HOLES FROM OVERLAP PART TO AREA WITH LESS HOLES WITH LARGER ABSOLUTE VALUE
202
SUPPLEMENT HOLES FROM OVERLAP PART TO AREA WITH LESS HOLES WITH SMALLER ABSOLUTE VALUE
203
DISTRIBUTE HOLES REMAINING AT OVERLAP PART EQUALLY AMONG LEFT AND RIGHT AREAS
204
END

# FIG.20

| | | | |
|---|---|---|---|
| LEFT AREA | f(1) | w(1) | g(1) |
| RIGHT AREA | f(2) | w(2) | g(2) |

A : SUPPLEMENT TO AREA WITH LARGER DIFFERENCE

B : SUPPLEMENT TO AREA WITH SMALLER DIFFERENCE

C : DISTRIBUTE REMAINING HOLES EQUALLY

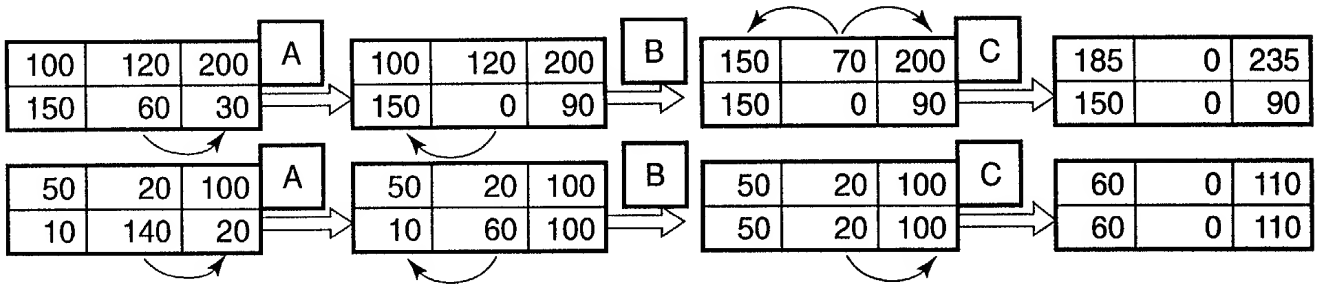


FIG.21

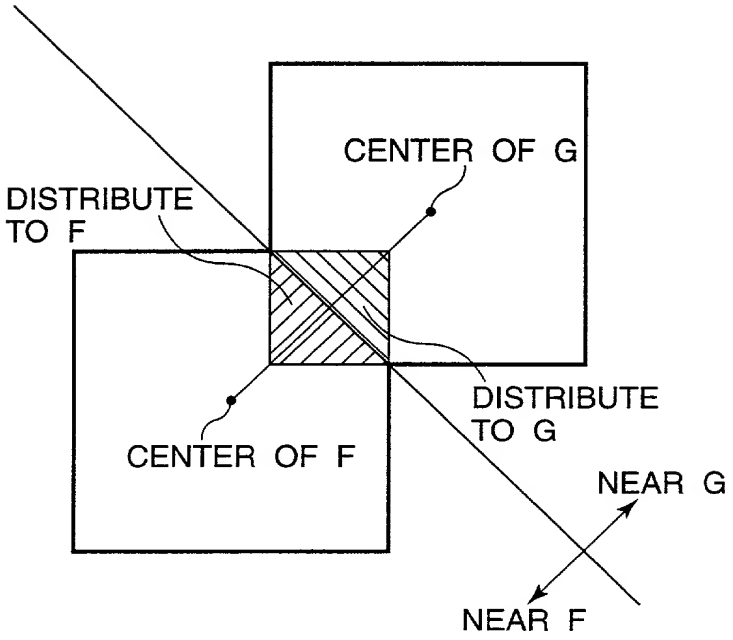

CENTER OF G
DISTRIBUTE
TO F
DISTRIBUTE
TO G
CENTER OF F
NEAR G
NEAR F

FIG.22

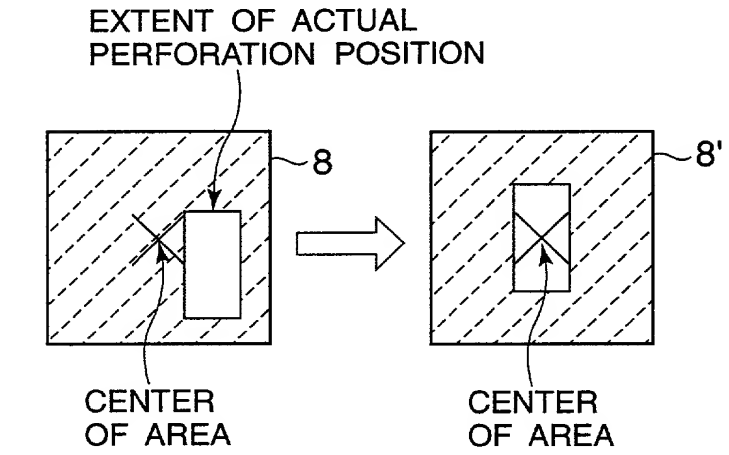

EXTENT OF ACTUAL PERFORATION POSITION
8
8'
CENTER OF AREA
CENTER OF AREA

FIG.23

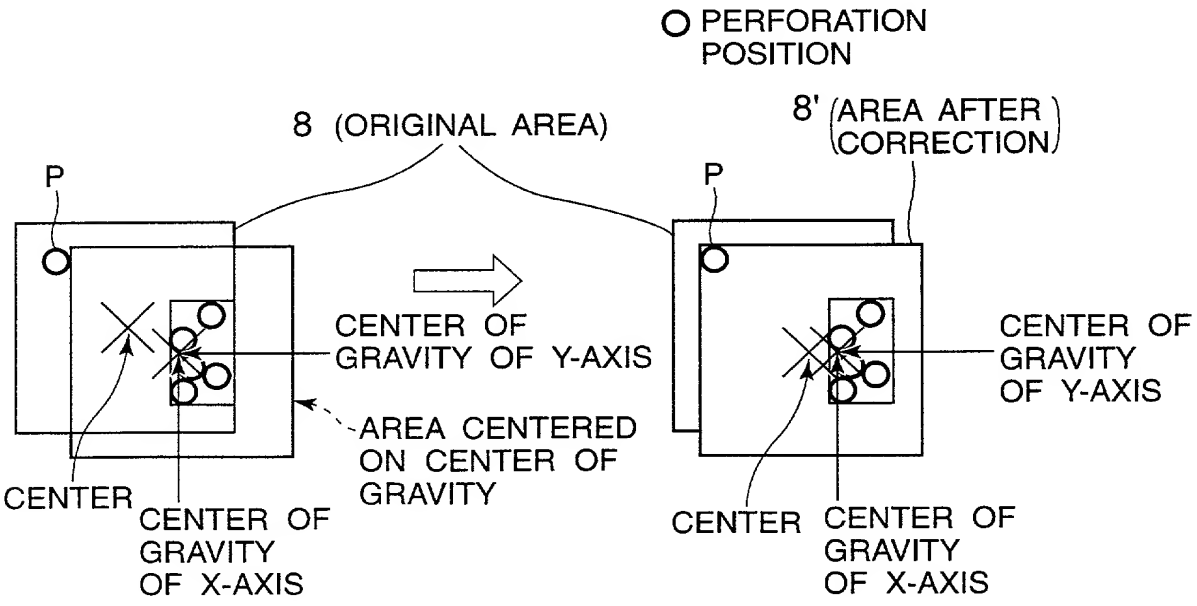

O PERFORATION POSITION
8 (ORIGINAL AREA)
8' (AREA AFTER CORRECTION)
P
P
CENTER OF GRAVITY OF Y-AXIS
AREA CENTERED ON CENTER OF GRAVITY
CENTER OF GRAVITY OF Y-AXIS
CENTER
CENTER OF GRAVITY OF X-AXIS
CENTER
CENTER OF GRAVITY OF X-AXIS

FIG.24

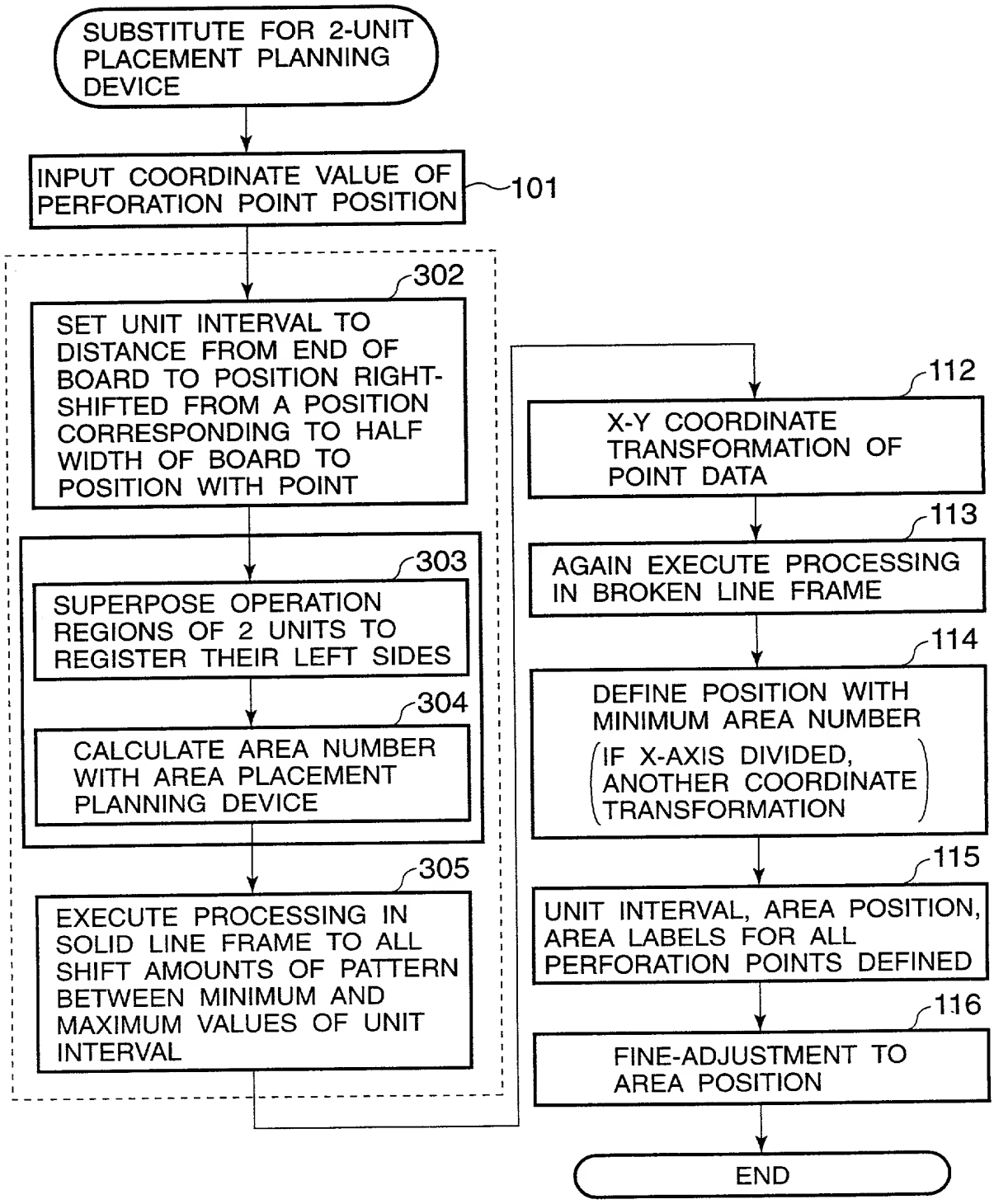

SUBSTITUTE FOR 2-UNIT PLACEMENT PLANNING DEVICE
INPUT COORDINATE VALUE OF PERFORATION POINT POSITION
101
302
SET UNIT INTERVAL TO DISTANCE FROM END OF BOARD TO POSITION RIGHT-SHIFTED FROM A POSITION CORRESPONDING TO HALF WIDTH OF BOARD TO POSITION WITH POINT
303
SUPERPOSE OPERATION REGIONS OF 2 UNITS TO REGISTER THEIR LEFT SIDES
304
CALCULATE AREA NUMBER WITH AREA PLACEMENT PLANNING DEVICE
305
EXECUTE PROCESSING IN SOLID LINE FRAME TO ALL SHIFT AMOUNTS OF PATTERN BETWEEN MINIMUM AND MAXIMUM VALUES OF UNIT INTERVAL
112
X-Y COORDINATE TRANSFORMATION OF POINT DATA
113
AGAIN EXECUTE PROCESSING IN BROKEN LINE FRAME
114
DEFINE POSITION WITH MINIMUM AREA NUMBER
(IF X-AXIS DIVIDED, ANOTHER COORDINATE TRANSFORMATION
115
UNIT INTERVAL, AREA POSITION, AREA LABELS FOR ALL PERFORATION POINTS DEFINED
116
FINE-ADJUSTMENT TO AREA POSITION
END

FIG.25

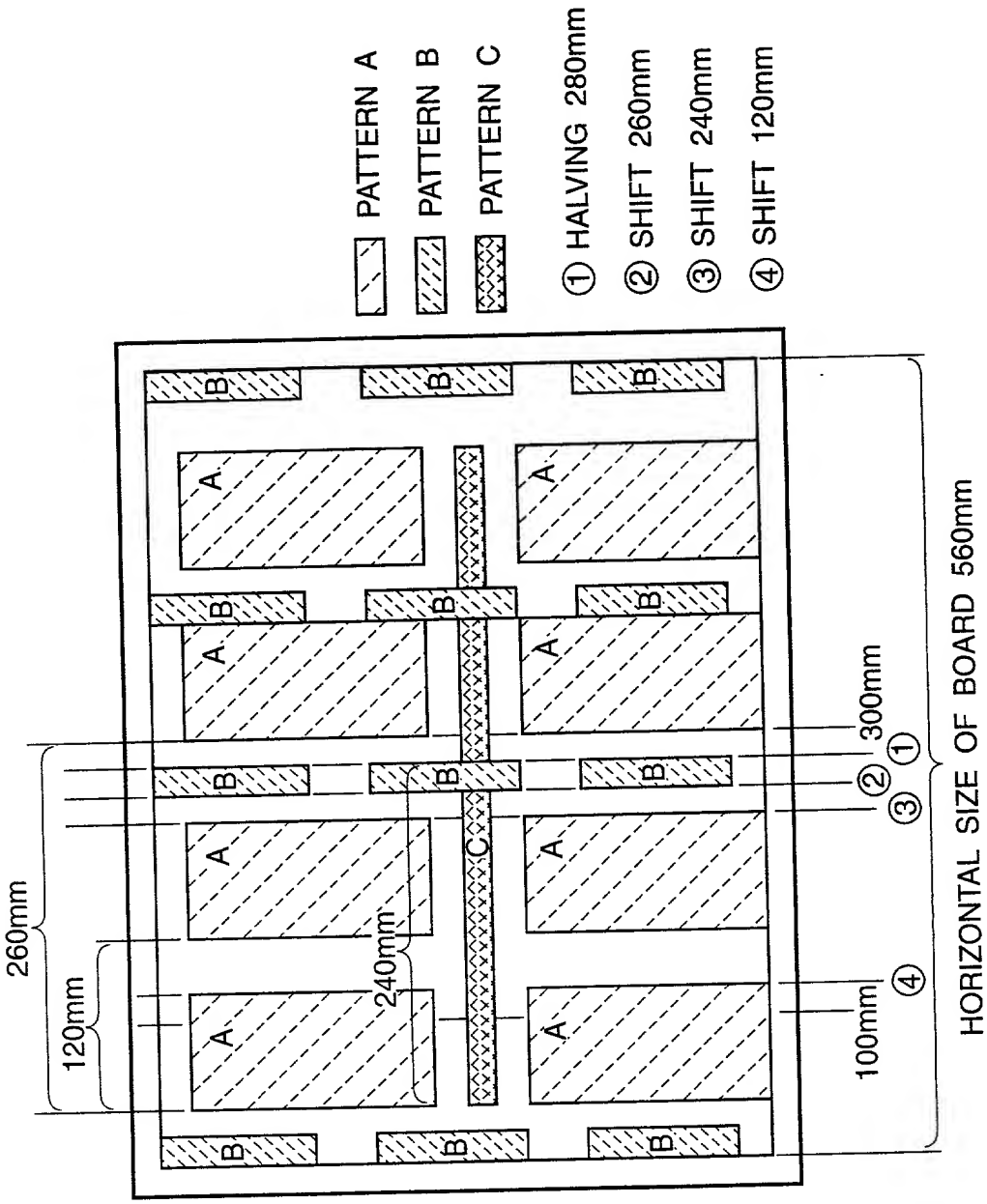

PATTERN A
PATTERN B
PATTERN C
① HALVING 280mm
② SHIFT 260mm
③ SHIFT 240mm
④ SHIFT 120mm
260mm
120mm
240mm
300mm
100mm
HORIZONTAL SIZE OF BOARD 560mm

FIG.26

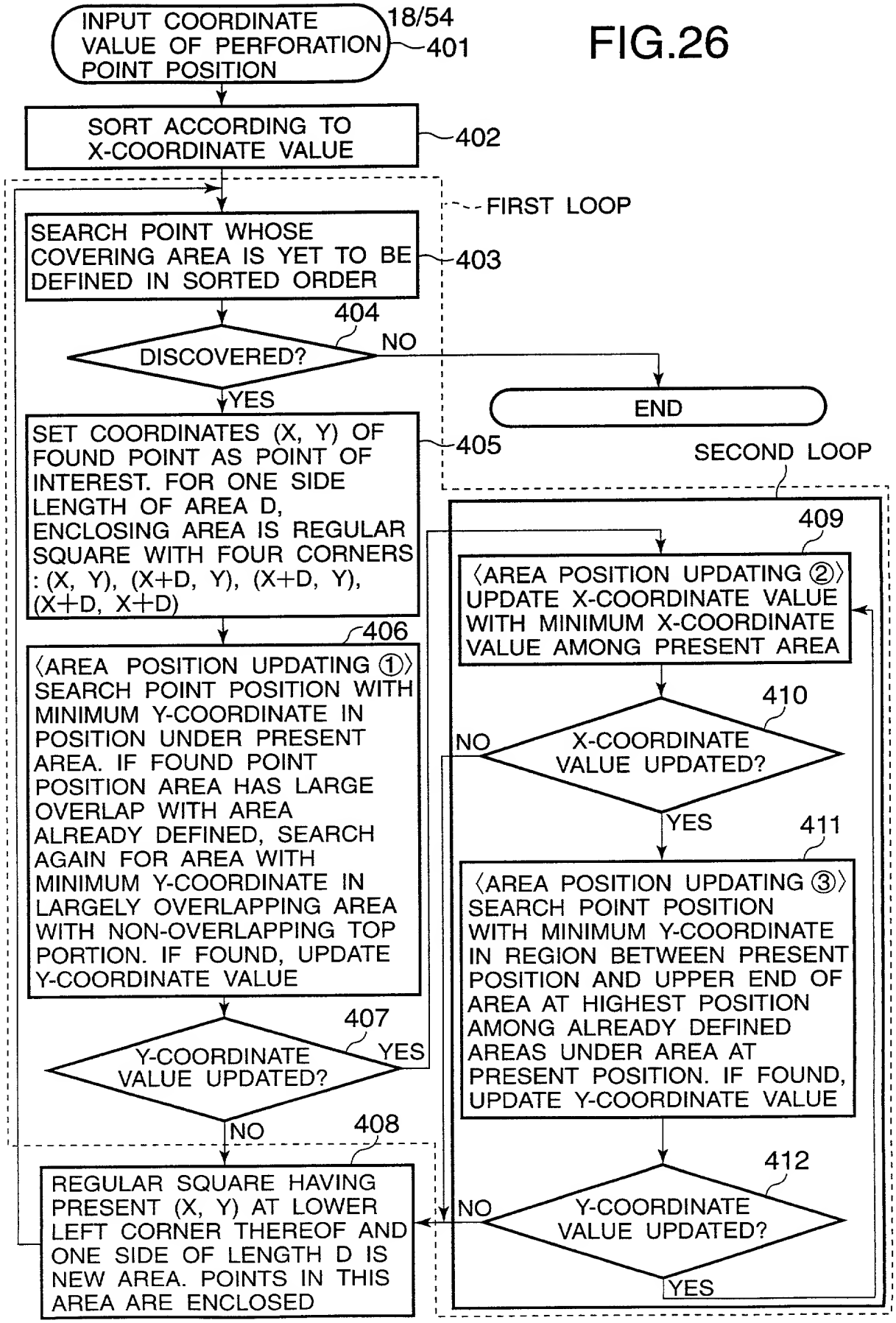

INPUT COORDINATE VALUE OF PERFORATION POINT POSITION
401
SORT ACCORDING TO X-COORDINATE VALUE
402
FIRST LOOP
SEARCH POINT WHOSE COVERING AREA IS YET TO BE DEFINED IN SORTED ORDER
403
404
DISCOVERED?
NO
YES
END
SET COORDINATES (X, Y) OF FOUND POINT AS POINT OF INTEREST. FOR ONE SIDE LENGTH OF AREA D, ENCLOSING AREA IS REGULAR SQUARE WITH FOUR CORNERS : (X, Y), (X+D, Y), (X+D, Y), (X+D, X+D)
405
SECOND LOOP
406
〈AREA POSITION UPDATING ①〉 SEARCH POINT POSITION WITH MINIMUM Y-COORDINATE IN POSITION UNDER PRESENT AREA. IF FOUND POINT POSITION AREA HAS LARGE OVERLAP WITH AREA ALREADY DEFINED, SEARCH AGAIN FOR AREA WITH MINIMUM Y-COORDINATE IN LARGELY OVERLAPPING AREA WITH NON-OVERLAPPING TOP PORTION. IF FOUND, UPDATE Y-COORDINATE VALUE
407
Y-COORDINATE VALUE UPDATED?
YES
NO
408
REGULAR SQUARE HAVING PRESENT (X, Y) AT LOWER LEFT CORNER THEREOF AND ONE SIDE OF LENGTH D IS NEW AREA. POINTS IN THIS AREA ARE ENCLOSED
409
〈AREA POSITION UPDATING ②〉 UPDATE X-COORDINATE VALUE WITH MINIMUM X-COORDINATE VALUE AMONG PRESENT AREA
410
X-COORDINATE VALUE UPDATED?
NO
YES
411
〈AREA POSITION UPDATING ③〉 SEARCH POINT POSITION WITH MINIMUM Y-COORDINATE IN REGION BETWEEN PRESENT POSITION AND UPPER END OF AREA AT HIGHEST POSITION AMONG ALREADY DEFINED AREAS UNDER AREA AT PRESENT POSITION. IF FOUND, UPDATE Y-COORDINATE VALUE
412
Y-COORDINATE VALUE UPDATED?
NO
YES

FIG.27

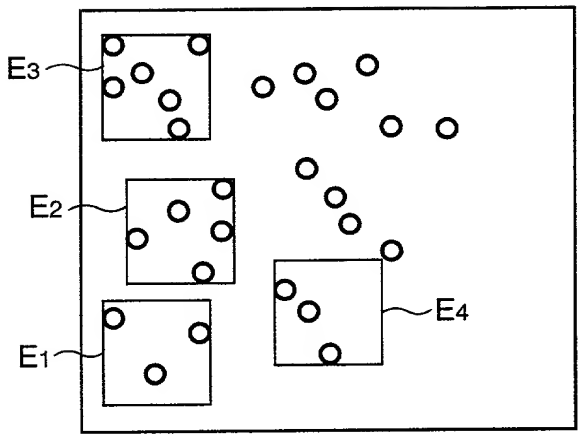



FIG.28

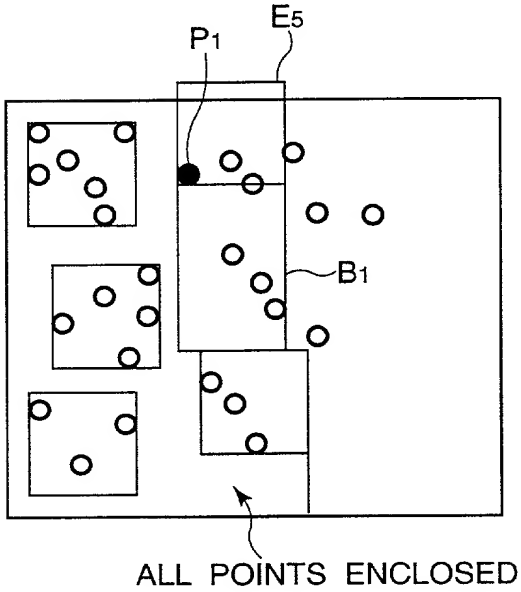


FIG.29

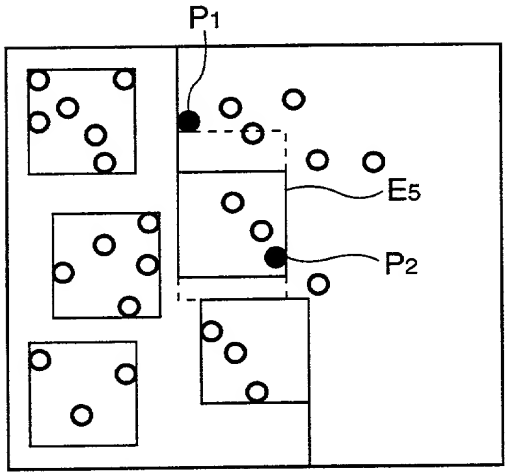

P1
E5
P2

FIG.30

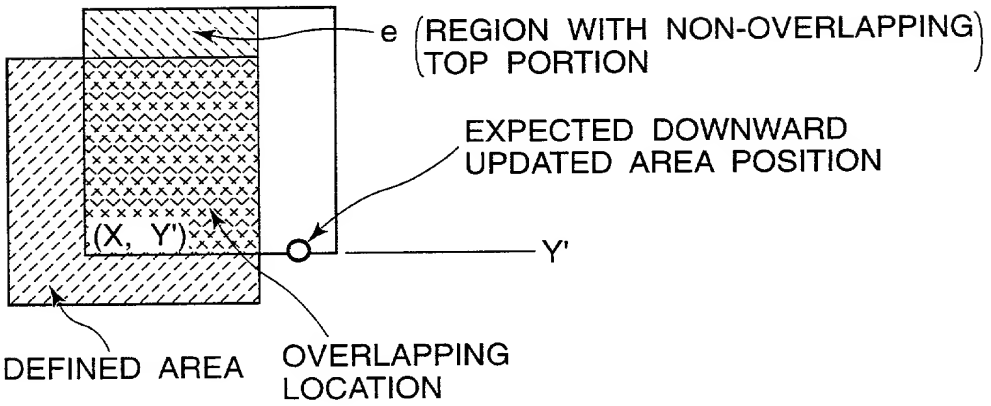

e (REGION WITH NON-OVERLAPPING TOP PORTION
EXPECTED DOWNWARD UPDATED AREA POSITION
(X, Y')
Y'
DEFINED AREA
OVERLAPPING LOCATION

FIG.31

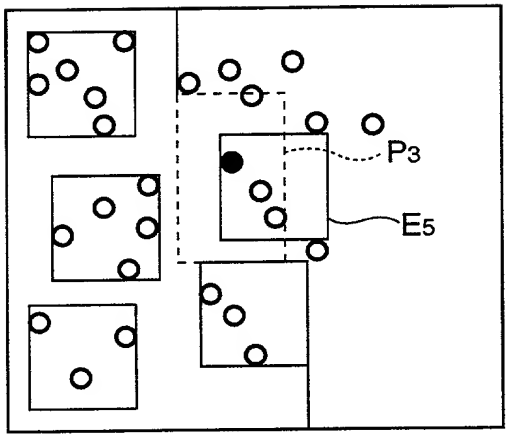

P3
E5

FIG.32

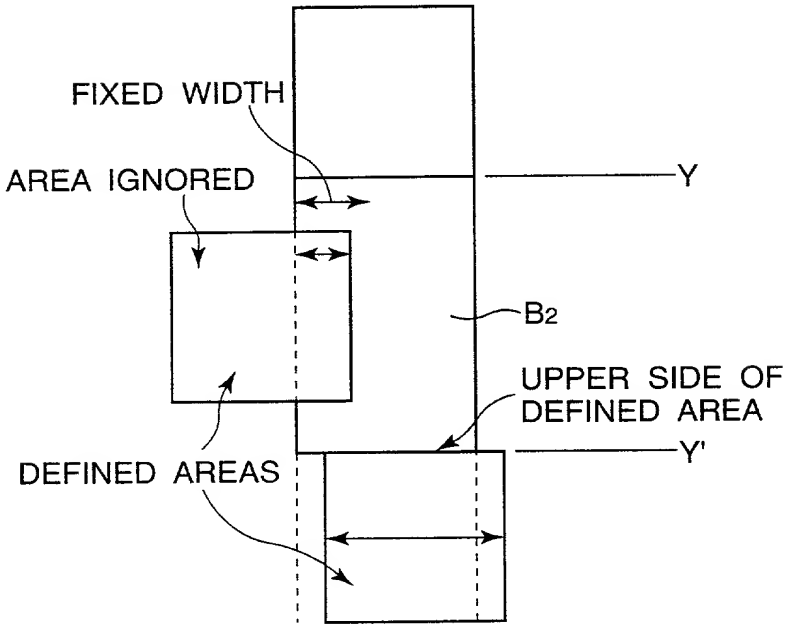

FIXED WIDTH
AREA IGNORED
Y
B2
UPPER SIDE OF DEFINED AREA
Y'
DEFINED AREAS

FIG.33

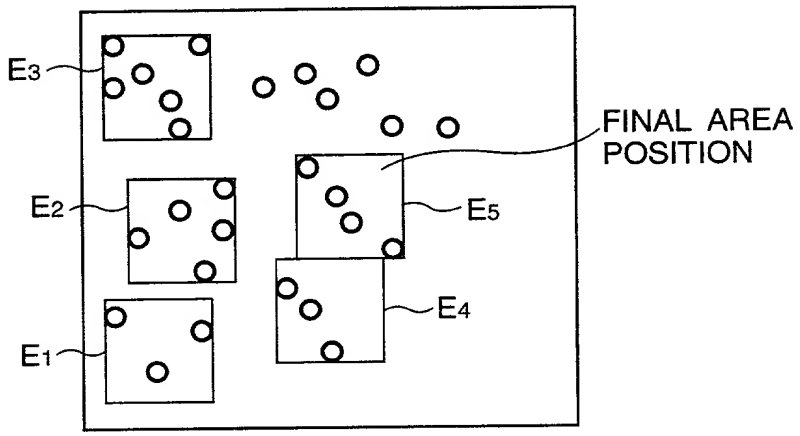


FIG.34A

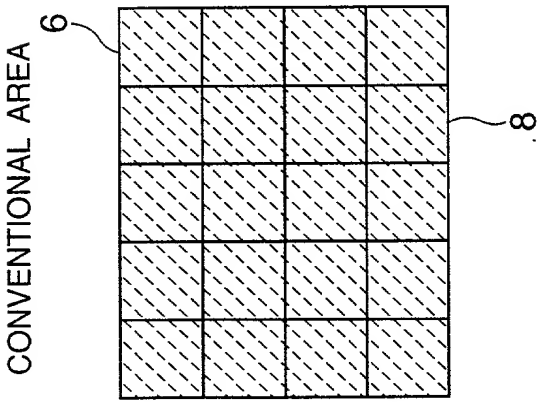



FIG.34B

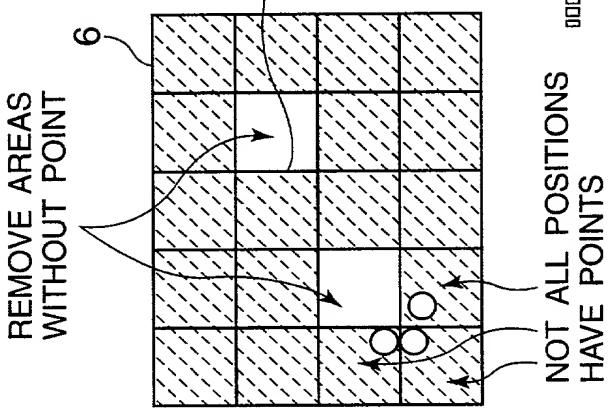



FIG.34C

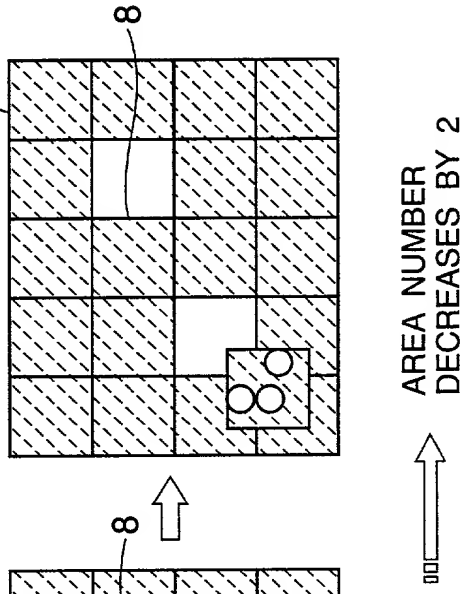


FIG.35

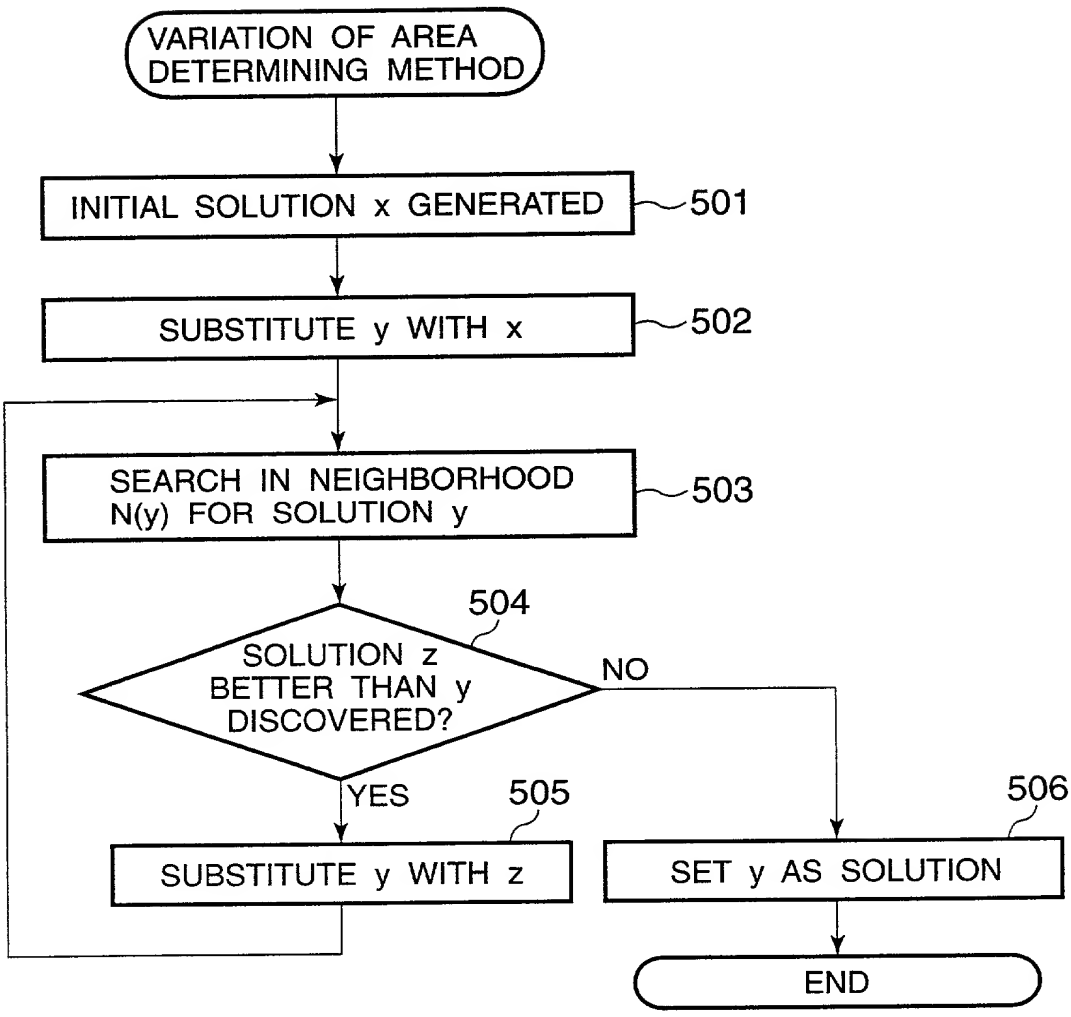

VARIATION OF AREA DETERMINING METHOD
INITIAL SOLUTION x GENERATED
501
SUBSTITUTE y WITH x
502
SEARCH IN NEIGHBORHOOD N(y) FOR SOLUTION y
503
504
SOLUTION z BETTER THAN y DISCOVERED?
NO
YES
505
506
SUBSTITUTE y WITH z
SET y AS SOLUTION
END

FIG.36

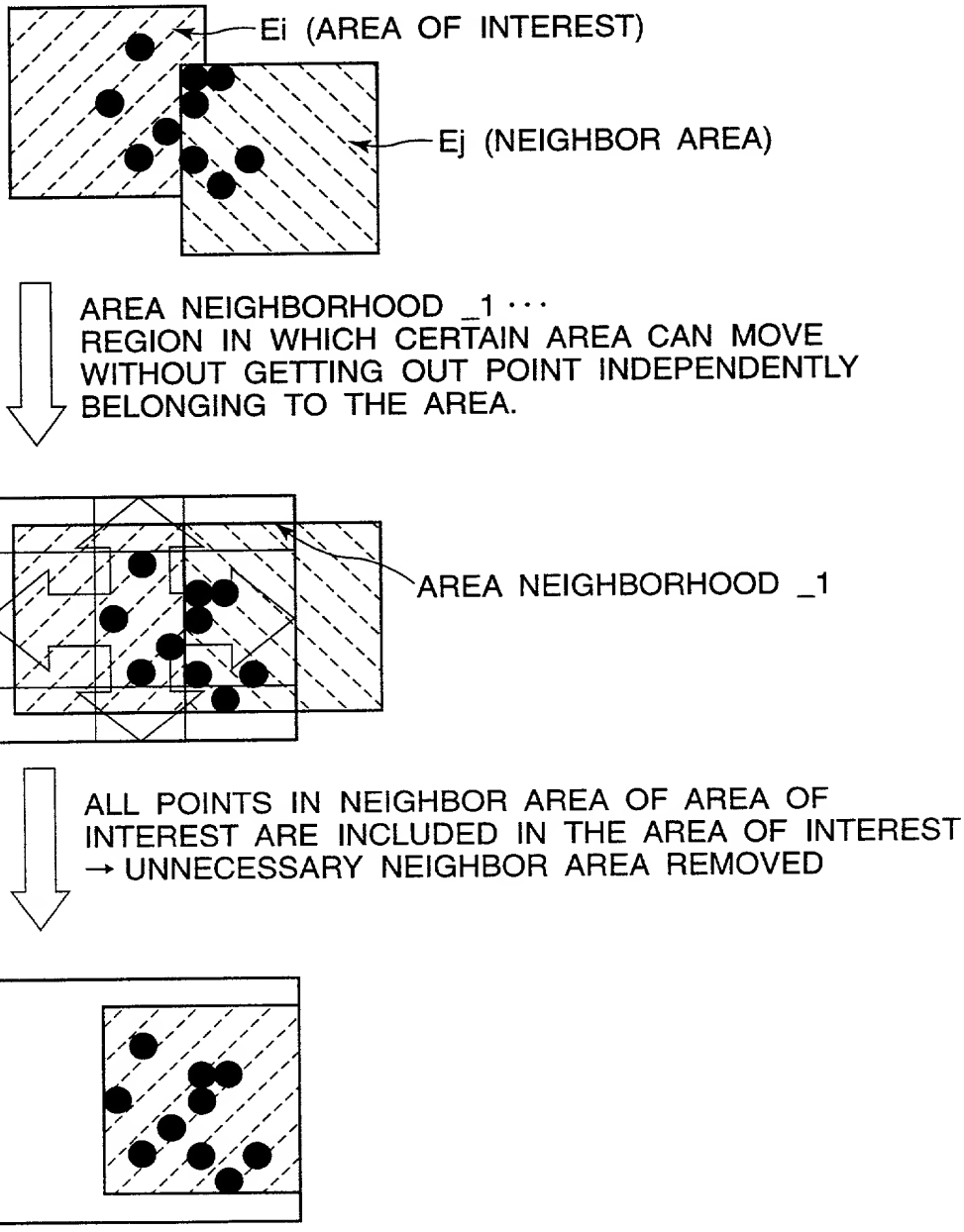

Ei (AREA OF INTEREST)
Ej (NEIGHBOR AREA)
AREA NEIGHBORHOOD _1 ···
REGION IN WHICH CERTAIN AREA CAN MOVE
WITHOUT GETTING OUT POINT INDEPENDENTLY
BELONGING TO THE AREA.
AREA NEIGHBORHOOD _1
ALL POINTS IN NEIGHBOR AREA OF AREA OF
INTEREST ARE INCLUDED IN THE AREA OF INTEREST
→ UNNECESSARY NEIGHBOR AREA REMOVED

FIG.37

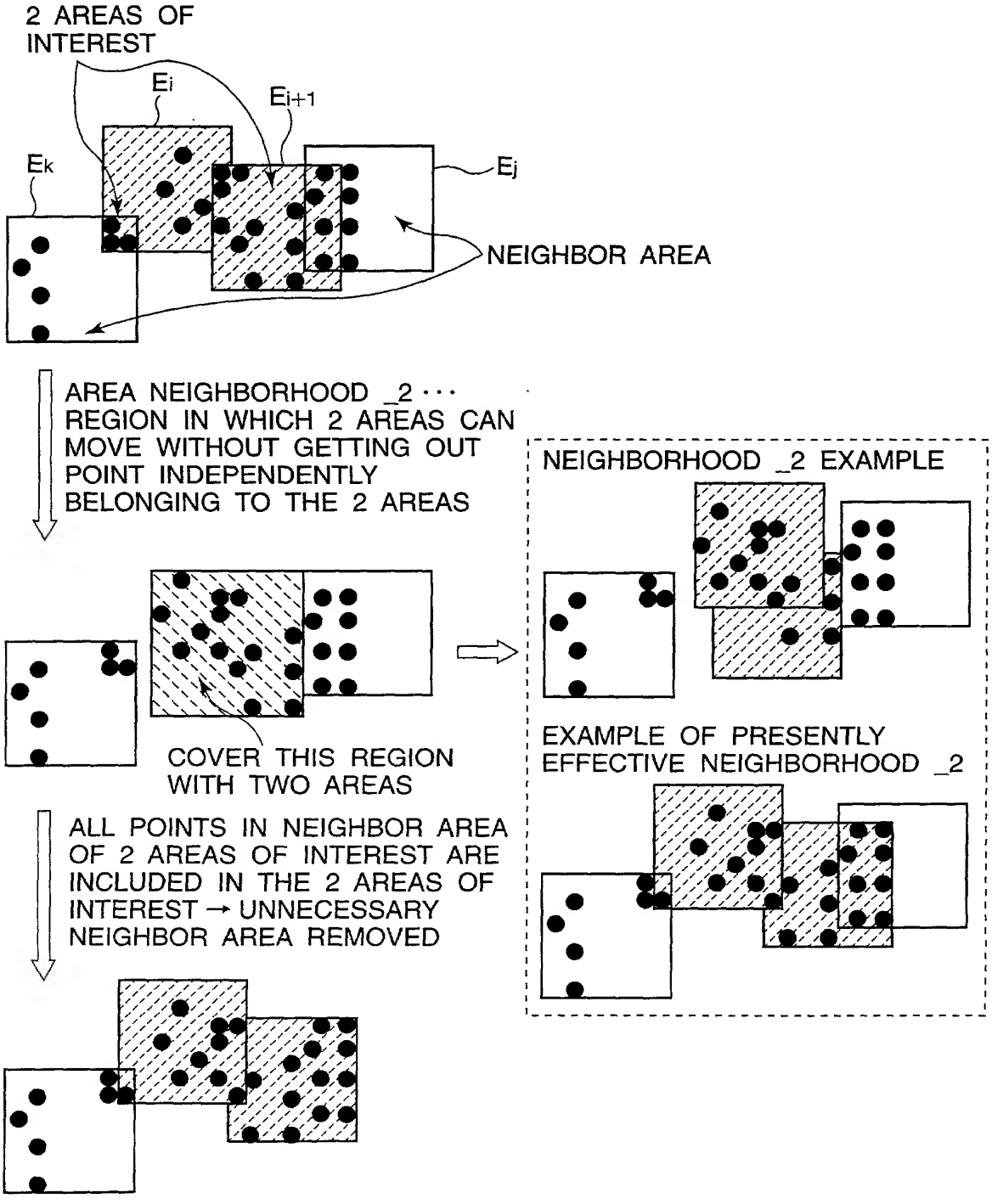

2 AREAS OF INTEREST
Ei
Ei+1
Ek
Ej
NEIGHBOR AREA
AREA NEIGHBORHOOD _2 ···
REGION IN WHICH 2 AREAS CAN MOVE WITHOUT GETTING OUT POINT INDEPENDENTLY BELONGING TO THE 2 AREAS
COVER THIS REGION WITH TWO AREAS
ALL POINTS IN NEIGHBOR AREA OF 2 AREAS OF INTEREST ARE INCLUDED IN THE 2 AREAS OF INTEREST → UNNECESSARY NEIGHBOR AREA REMOVED
NEIGHBORHOOD _2 EXAMPLE
EXAMPLE OF PRESENTLY EFFECTIVE NEIGHBORHOOD _2

FIG.38

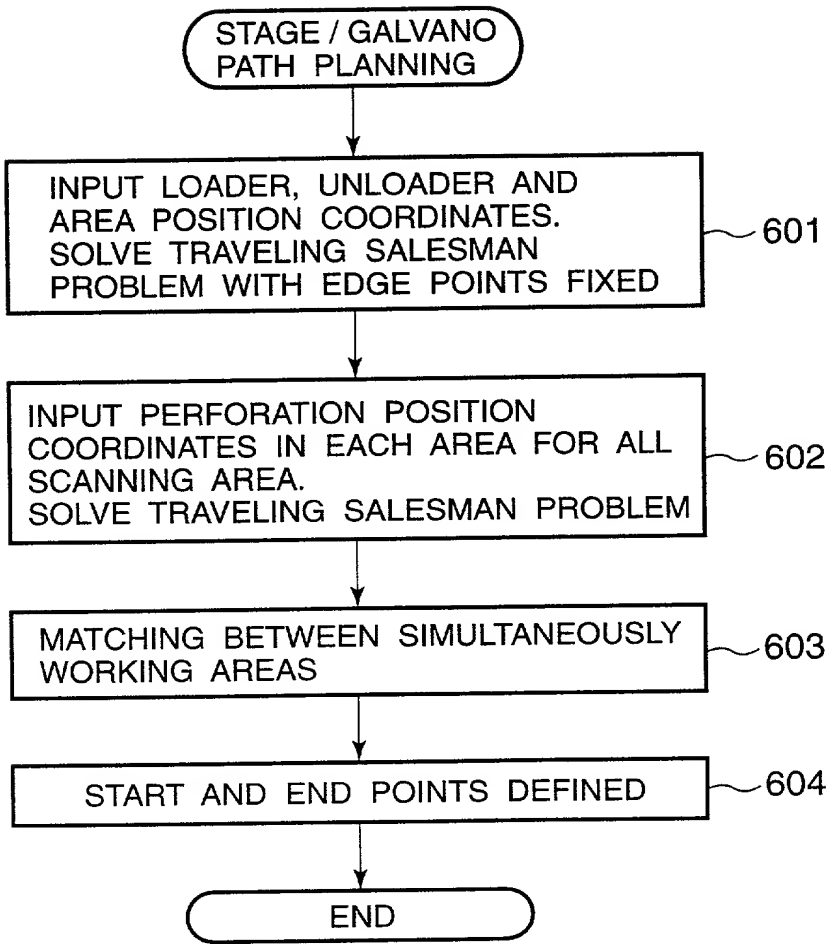

STAGE / GALVANO PATH PLANNING
INPUT LOADER, UNLOADER AND AREA POSITION COORDINATES. SOLVE TRAVELING SALESMAN PROBLEM WITH EDGE POINTS FIXED
601
INPUT PERFORATION POSITION COORDINATES IN EACH AREA FOR ALL SCANNING AREA. SOLVE TRAVELING SALESMAN PROBLEM
602
MATCHING BETWEEN SIMULTANEOUSLY WORKING AREAS
603
START AND END POINTS DEFINED
604
END

FIG.39

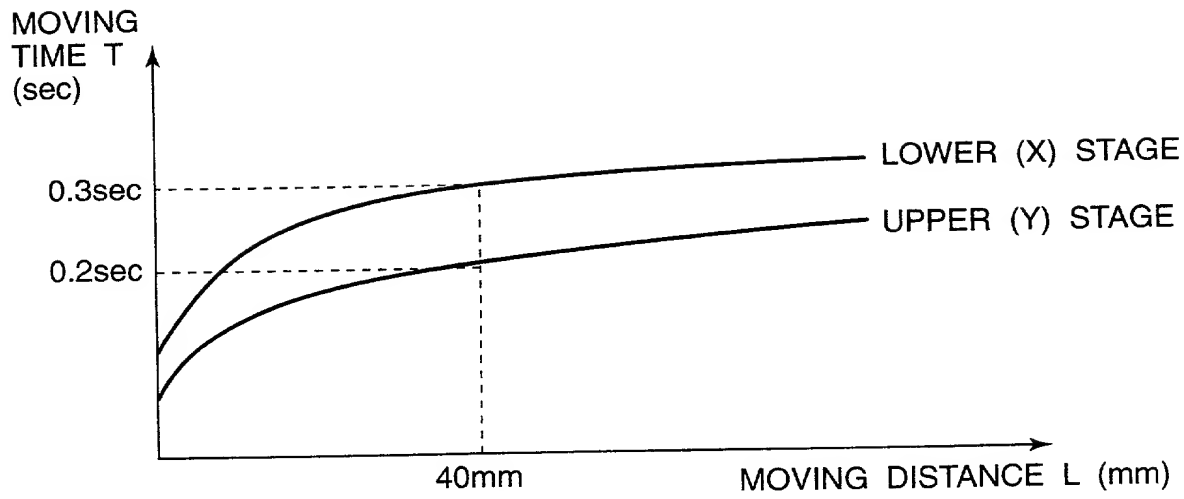
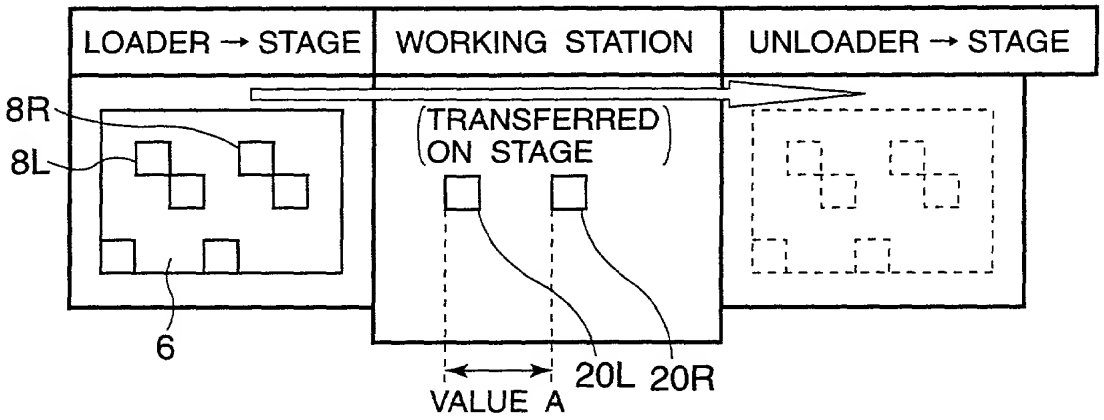
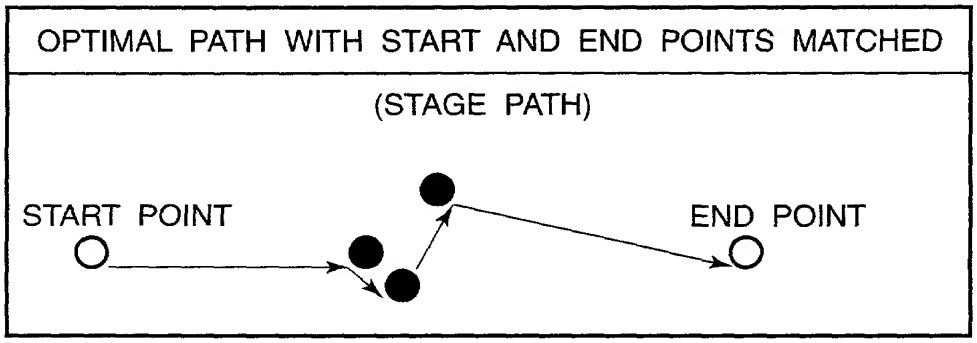

MOVING
TIME T
(sec)
0.3sec
0.2sec
LOWER (X) STAGE
UPPER (Y) STAGE
40mm
MOVING DISTANCE L (mm)

FIG.40


LOADER → STAGE
WORKING STATION
UNLOADER → STAGE
8R
8L
6
(TRANSFERRED ON STAGE)
20L
20R
VALUE A


OPTIMAL PATH WITH START AND END POINTS MATCHED
(STAGE PATH)
START POINT
END POINT

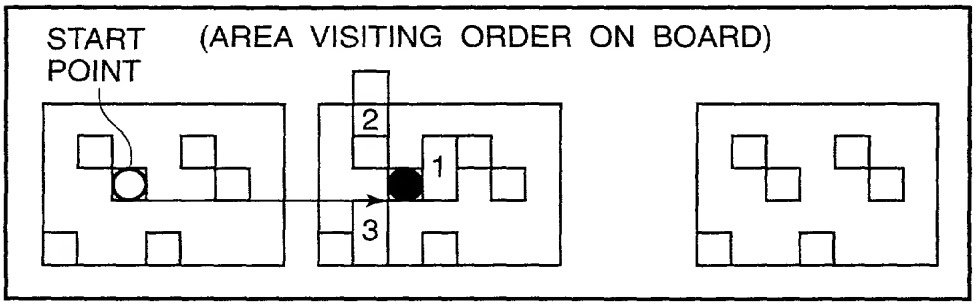

START POINT
(AREA VISITING ORDER ON BOARD)
2
1
3

FIG.41

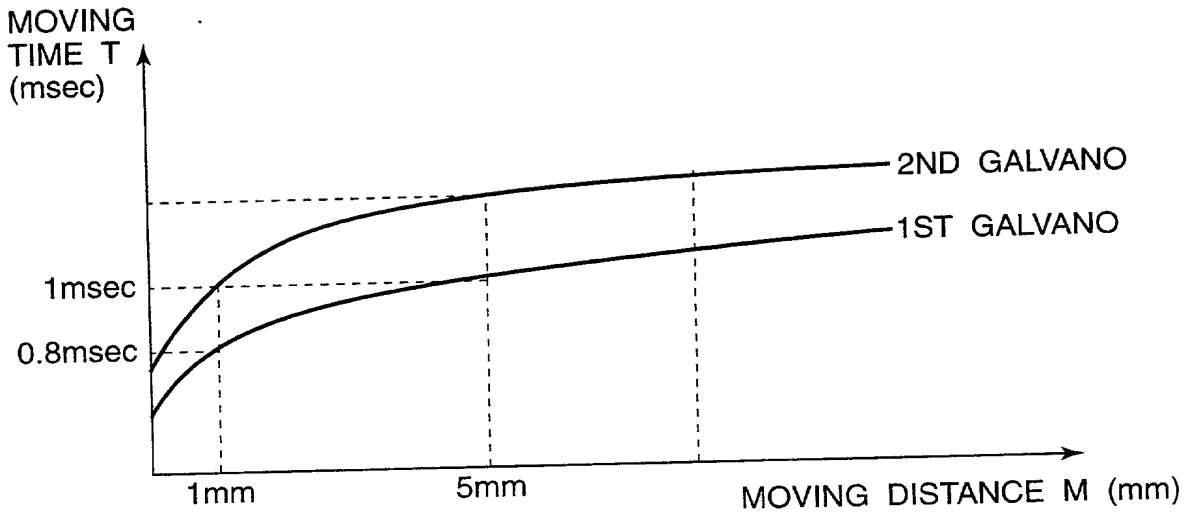
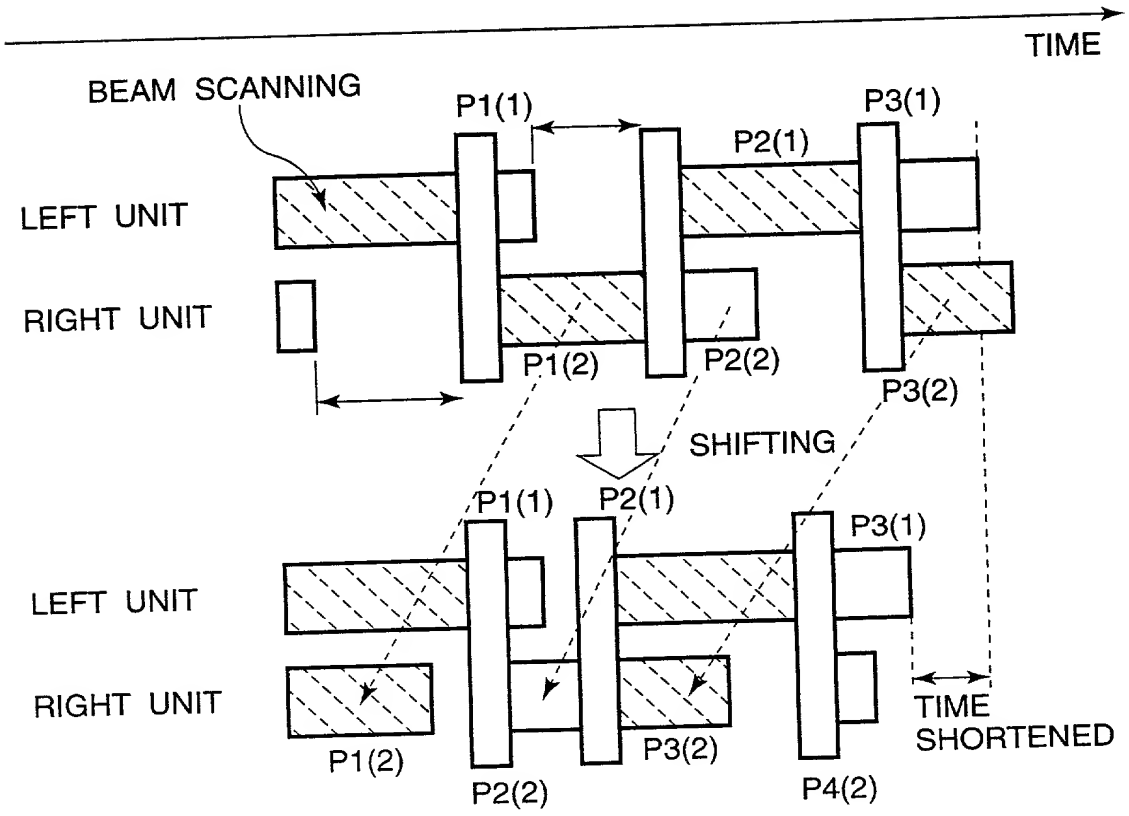

MOVING
TIME T
(msec)
2ND GALVANO
1ST GALVANO
1msec
0.8msec
1mm
5mm
MOVING DISTANCE M (mm)

FIG.42


TIME
BEAM SCANNING
P1(1)
P2(1)
P3(1)
LEFT UNIT
RIGHT UNIT
P1(2)
P2(2)
P3(2)
SHIFTING
P1(1)
P2(1)
P3(1)
LEFT UNIT
RIGHT UNIT
P1(2)
P2(2)
P3(2)
P4(2)
TIME
SHORTENED

# FIG.43

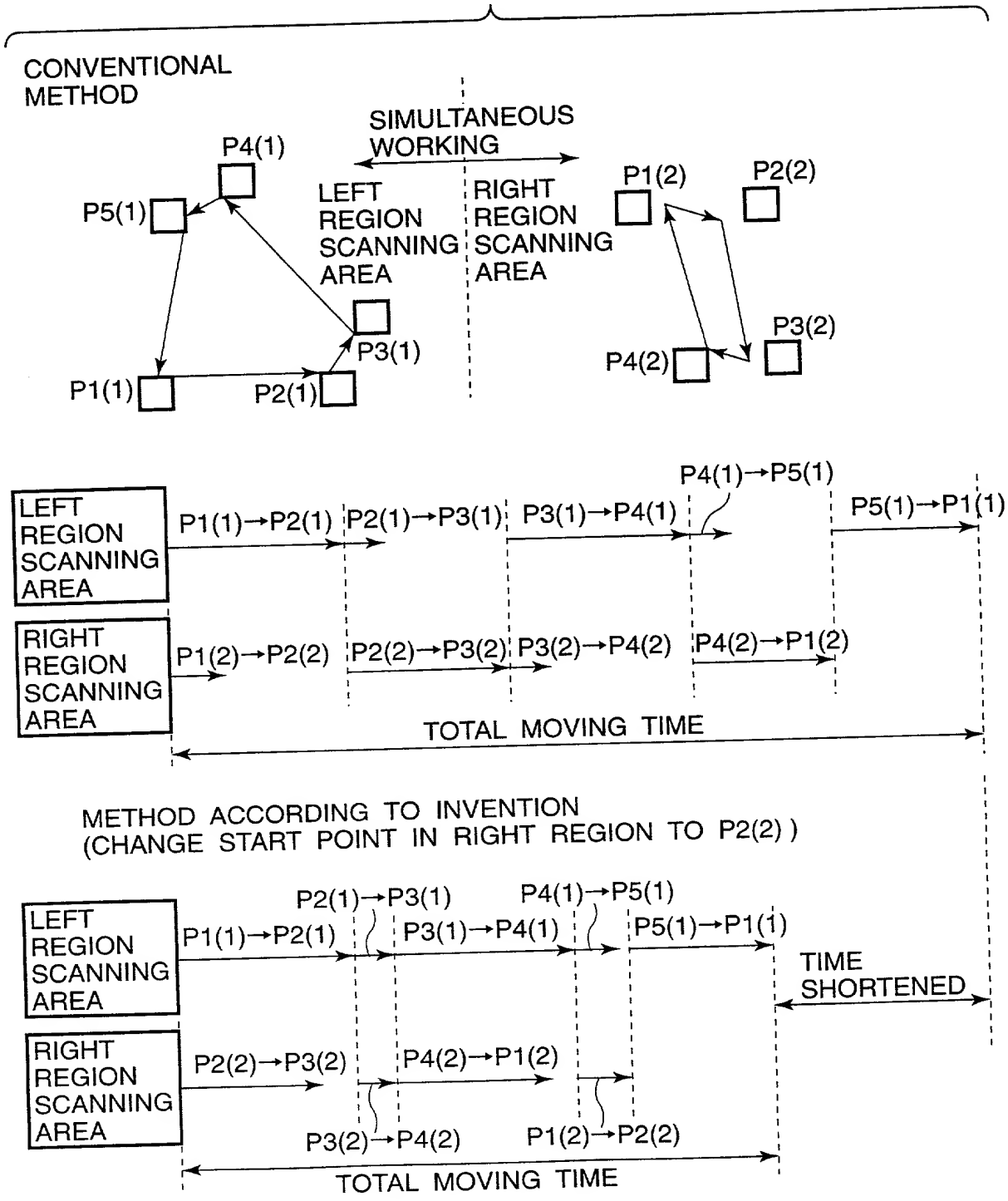

CONVENTIONAL METHOD
SIMULTANEOUS WORKING
LEFT REGION SCANNING AREA
RIGHT REGION SCANNING AREA
P4(1)
P5(1)
P3(1)
P1(1)
P2(1)
P1(2)
P2(2)
P3(2)
P4(2)
LEFT REGION SCANNING AREA
RIGHT REGION SCANNING AREA
P1(1)→P2(1)
P2(1)→P3(1)
P3(1)→P4(1)
P4(1)→P5(1)
P5(1)→P1(1)
P1(2)→P2(2)
P2(2)→P3(2)
P3(2)→P4(2)
P4(2)→P1(2)
TOTAL MOVING TIME
METHOD ACCORDING TO INVENTION
(CHANGE START POINT IN RIGHT REGION TO P2(2))
LEFT REGION SCANNING AREA
RIGHT REGION SCANNING AREA
P1(1)→P2(1)
P2(1)→P3(1)
P3(1)→P4(1)
P4(1)→P5(1)
P5(1)→P1(1)
P2(2)→P3(2)
P3(2)→P4(2)
P4(2)→P1(2)
P1(2)→P2(2)
TIME SHORTENED
TOTAL MOVING TIME

FIG.44

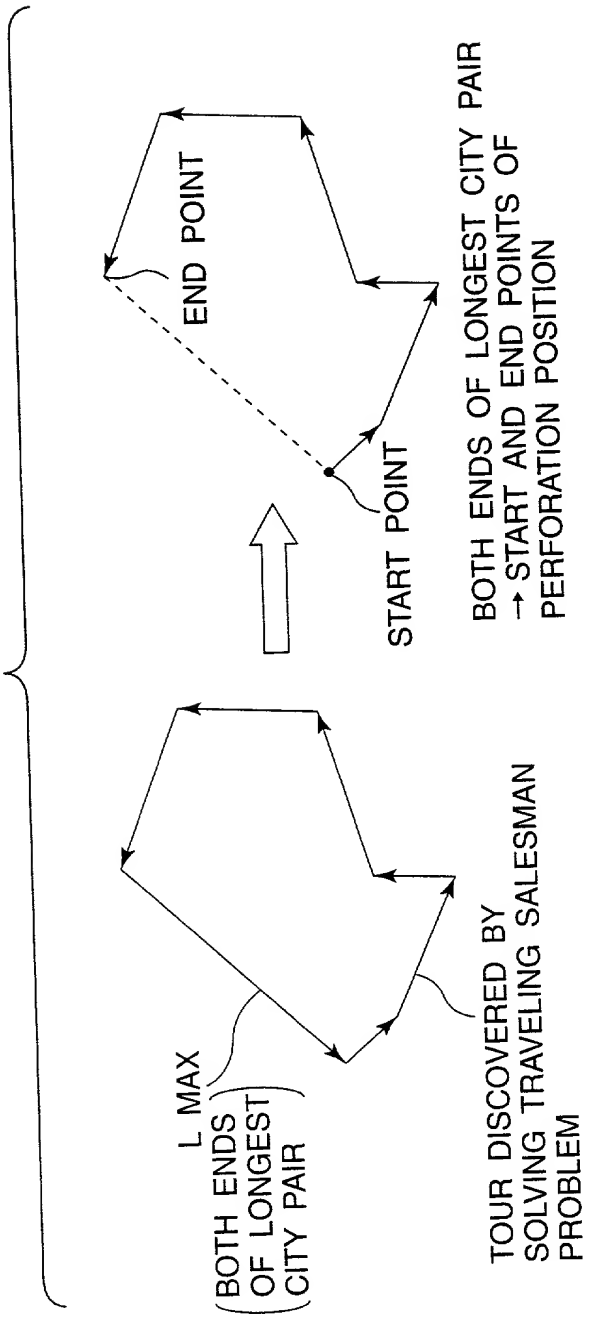
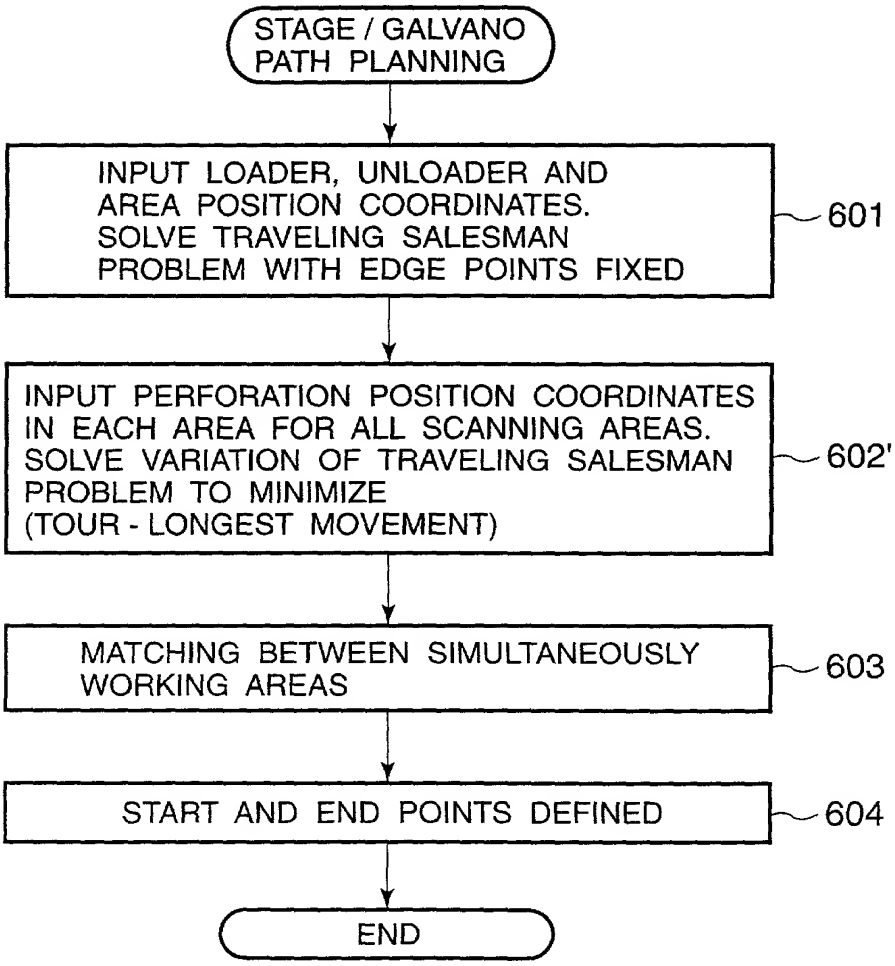
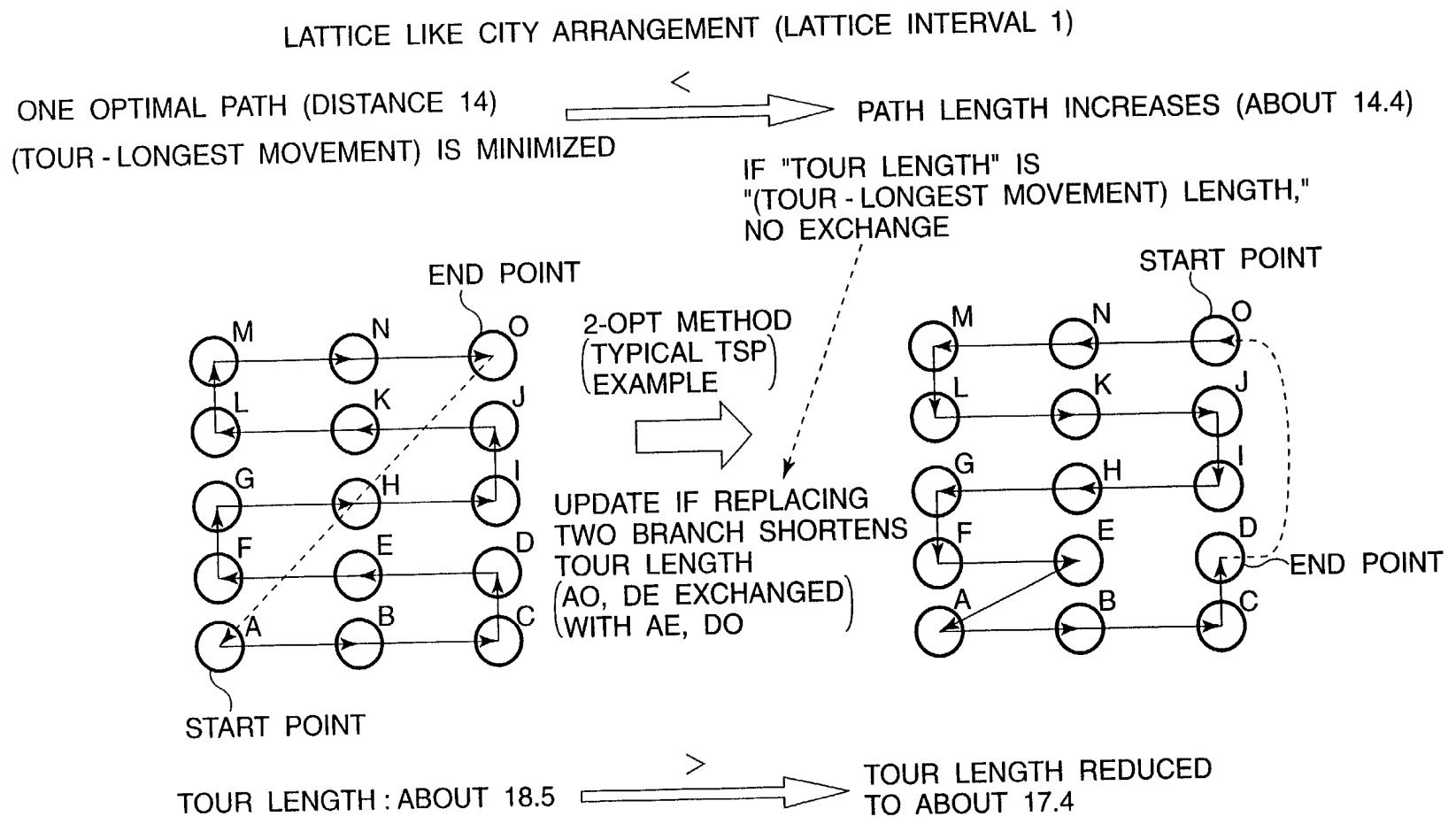

L MAX
(BOTH ENDS OF LONGEST CITY PAIR
TOUR DISCOVERED BY SOLVING TRAVELING SALESMAN PROBLEM
END POINT
START POINT
BOTH ENDS OF LONGEST CITY PAIR → START AND END POINTS OF PERFORATION POSITION

FIG.45

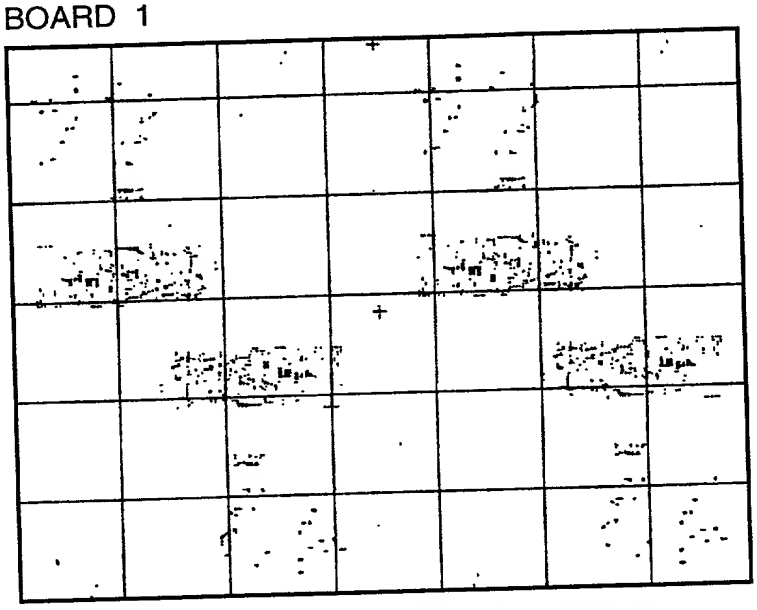

STAGE / GALVANO PATH PLANNING
INPUT LOADER, UNLOADER AND AREA POSITION COORDINATES. SOLVE TRAVELING SALESMAN PROBLEM WITH EDGE POINTS FIXED
601
INPUT PERFORATION POSITION COORDINATES IN EACH AREA FOR ALL SCANNING AREAS. SOLVE VARIATION OF TRAVELING SALESMAN PROBLEM TO MINIMIZE (TOUR - LONGEST MOVEMENT)
602'
MATCHING BETWEEN SIMULTANEOUSLY WORKING AREAS
603
START AND END POINTS DEFINED
604
END

# FIG.46

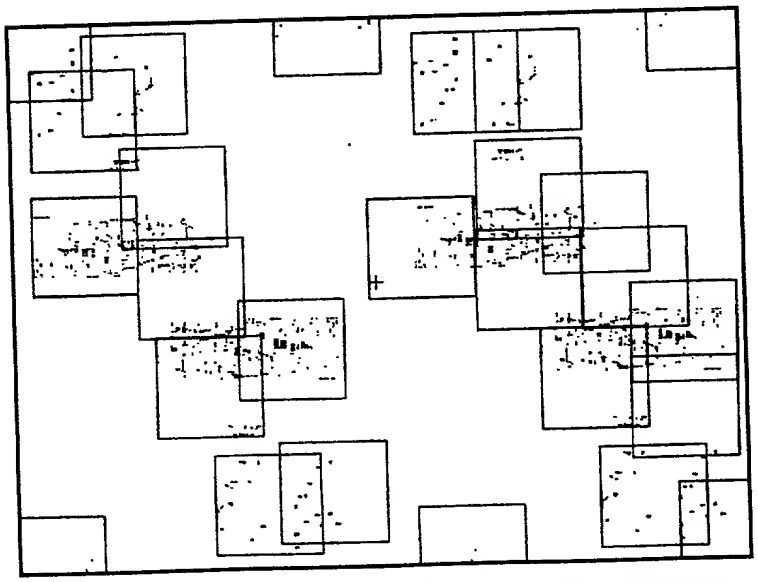

LATTICE LIKE CITY ARRANGEMENT (LATTICE INTERVAL 1)
ONE OPTIMAL PATH (DISTANCE 14)
(TOUR - LONGEST MOVEMENT) IS MINIMIZED
<
PATH LENGTH INCREASES (ABOUT 14.4)
IF "TOUR LENGTH" IS
"(TOUR - LONGEST MOVEMENT) LENGTH,"
NO EXCHANGE
END POINT
START POINT
2-OPT METHOD
(TYPICAL TSP
EXAMPLE)
UPDATE IF REPLACING
TWO BRANCH SHORTENS
TOUR LENGTH
(AO, DE EXCHANGED
WITH AE, DO)
M
N
O
L
K
J
G
H
I
F
E
D
A
B
C
START POINT
END POINT
TOUR LENGTH : ABOUT 18.5
>
TOUR LENGTH REDUCED
TO ABOUT 17.4

# FIG.47

BOARD 1



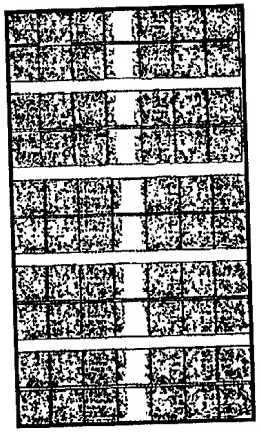
CONVENTIONAL CASE (42 AREAS)



PRESENT INVENTION APPLIED (26 AREAS)

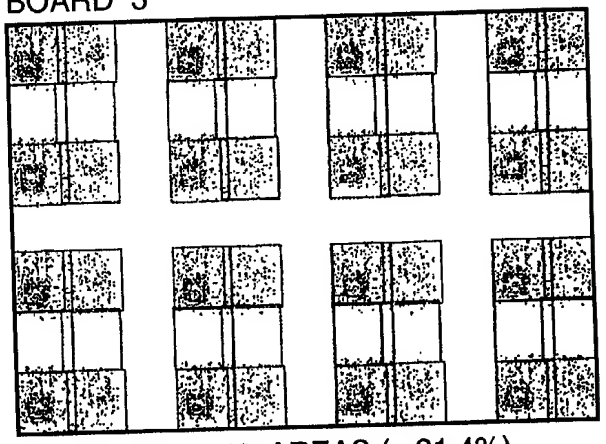
FIG.48

BOARD 2



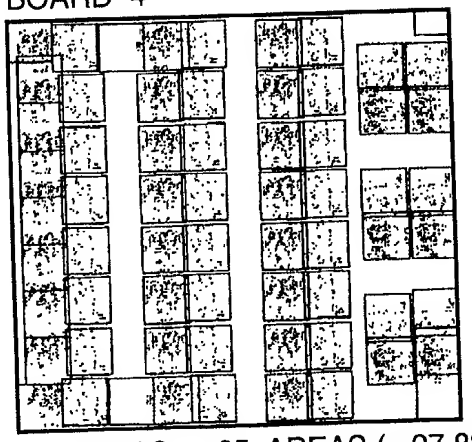
77 AREAS → 70 AREAS (−9.1%)

BOARD 3



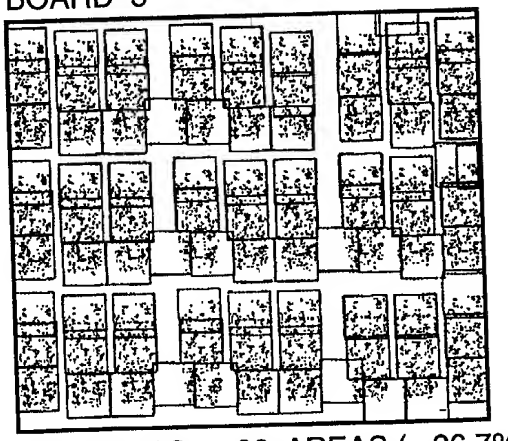
70 AREAS → 48 AREAS (−31.4%)

BOARD 4



90 AREAS → 65 AREAS (−27.8%)

BOARD 5



120 AREAS → 88 AREAS (−26.7%)

FIG.49

| | PERFORATION POSITION NUMBER | CONVENTIONAL METHOD | PRESENT INVENTION | REDUCTION PERCENTAGE (%) |
|---|---|---|---|---|
| BOARD 1 | 2746 | 42 | 26 | 38.1 |
| BOARD 2 | 39640 | 77 | 70 | 9.1 |
| BOARD 3 | 11904 | 70 | 48 | 31.4 |
| BOARD 4 | 15278 | 90 | 65 | 27.8 |
| BOARD 5 | 17886 | 120 | 88 | 26.7 |

FIG.51

| | UNIT INTERVAL (mm) | BEAM SCANNING NUMBER | STAGE MOVING NUMBER |
|---|---|---|---|
| HALVING (CONVENTIONAL METHOD 1) | 220.88 | 26111 | 71 |
| HEAD OF PATTERN (CONVENTIONAL METHOD 2) | 242.29 | 26900 | 71 |
| OPTIMAL POSITION (PRESENT INVENTION) | 211.34 | 24555 | 71 |

FIG.54

| PERFORATION POSITION NUMBER | CONVENTIONAL METHOD | METHOD ACCORDING TO INVENTION | IMPROVEMENT |
|---|---|---|---|
| 100 | 4519 | 2838 | 62.8 |
| 500 | 1697 | 1190 | 70.1 |
| 1000 | 1445 | 849 | 58.8 |
| (UNIT) | $\mu$m | $\mu$m | % |

FIG.50

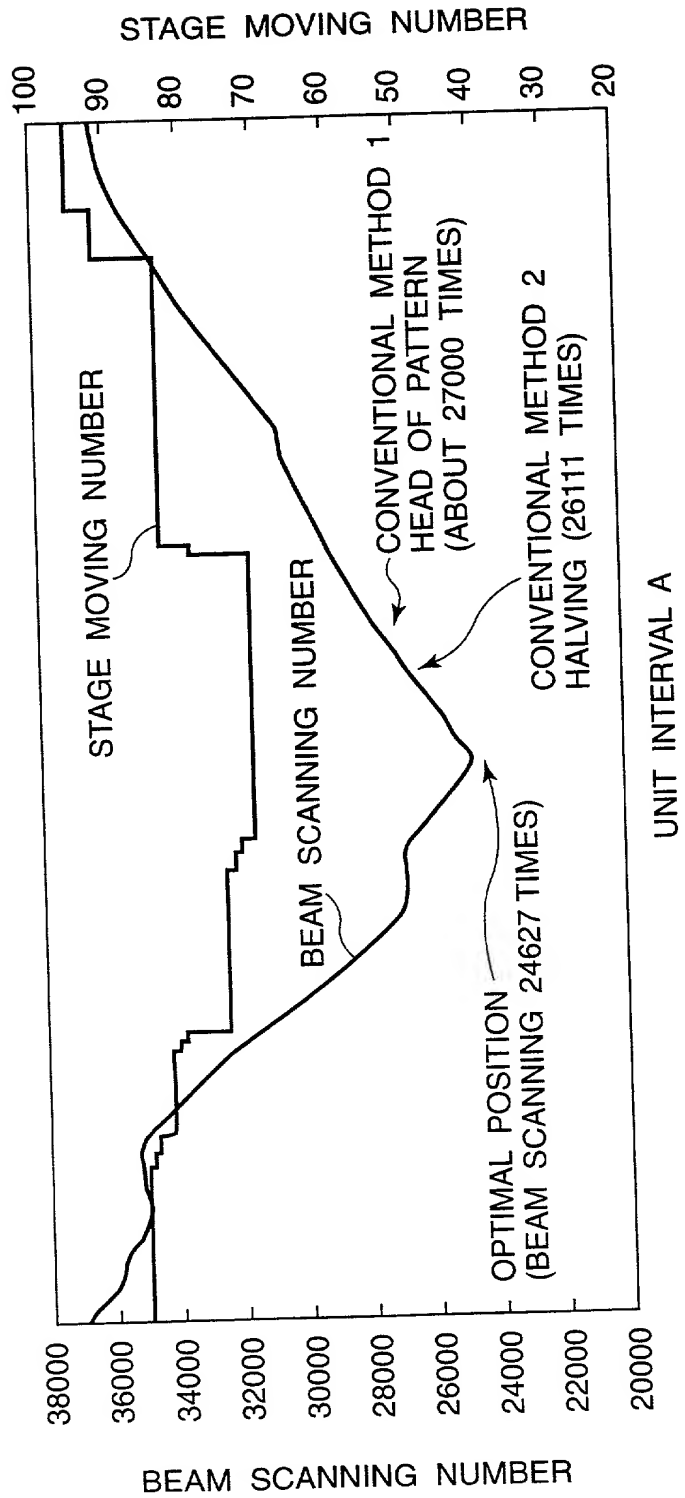
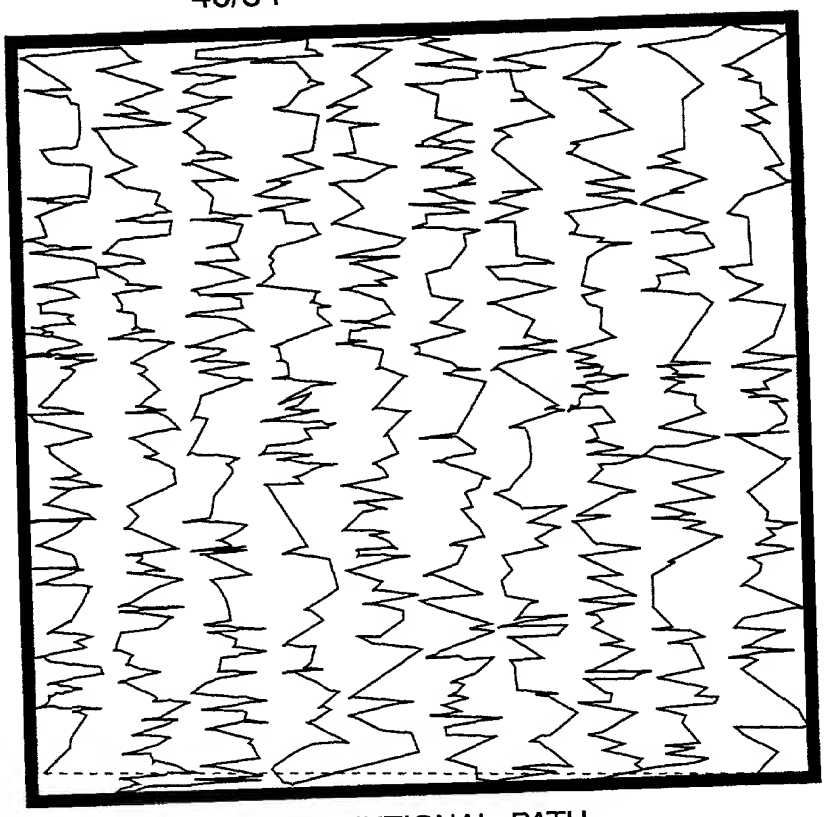
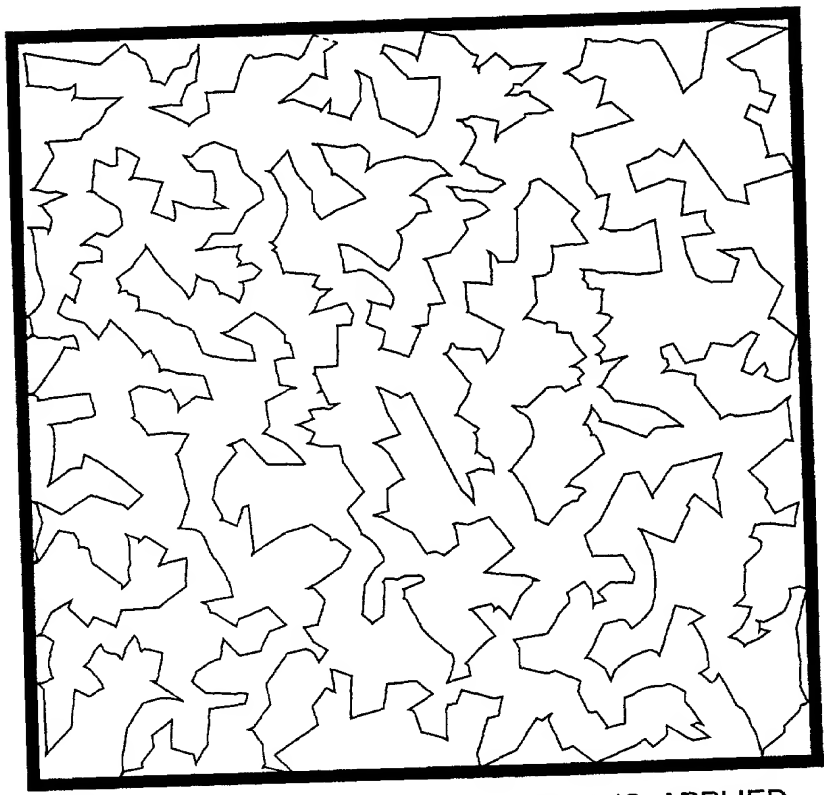

STAGE MOVING NUMBER
100
90
80
70
60
50
40
30
20
STAGE MOVING NUMBER
BEAM SCANNING NUMBER
CONVENTIONAL METHOD 1
HEAD OF PATTERN
(ABOUT 27000 TIMES)
CONVENTIONAL METHOD 2
HALVING (26111 TIMES)
OPTIMAL POSITION
(BEAM SCANNING 24627 TIMES)
38000
36000
34000
32000
30000
28000
26000
24000
22000
20000
BEAM SCANNING NUMBER
UNIT INTERVAL A

FIG.52



CONVENTIONAL PATH



PATH AFTER PRESENT INVENTION IS APPLIED
(ACCORDING TO 3-OPT METHOD)

FIG.53

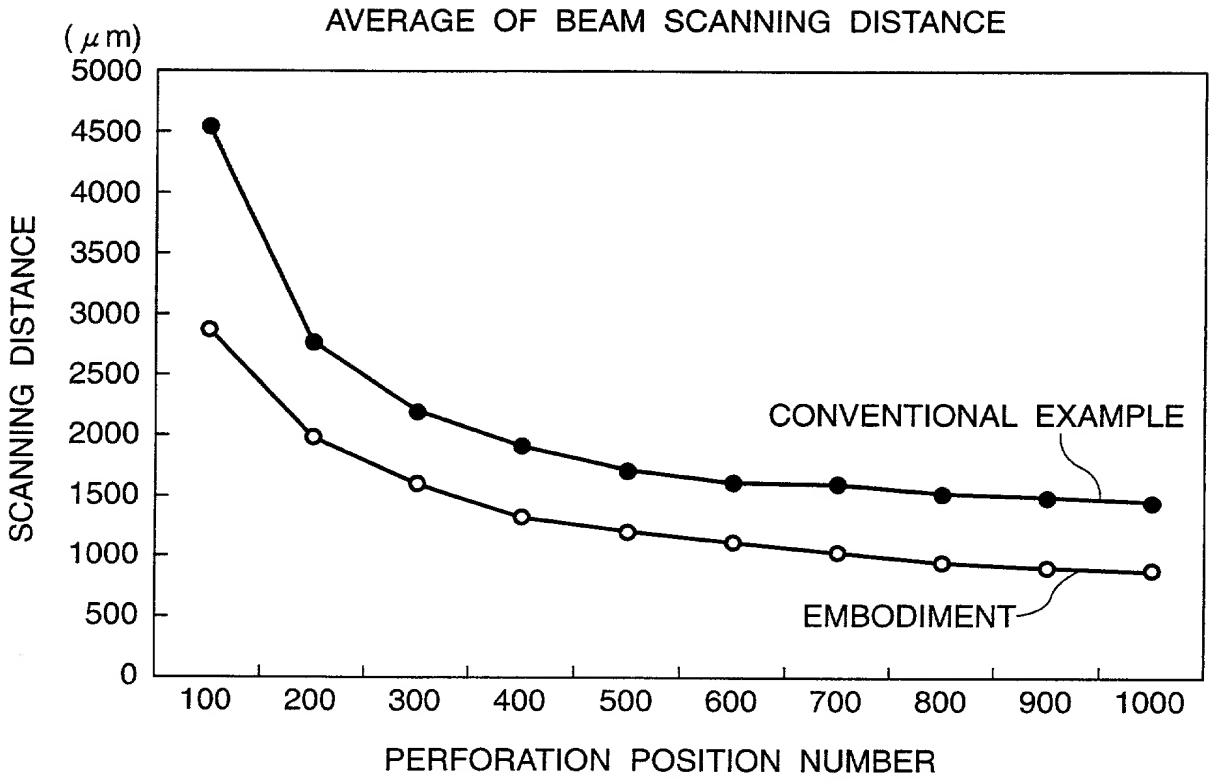

AVERAGE OF BEAM SCANNING DISTANCE
(μm)
SCANNING DISTANCE
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
100
200
300
400
500
600
700
800
900
1000
PERFORATION POSITION NUMBER
CONVENTIONAL EXAMPLE
EMBODIMENT

FIG.55

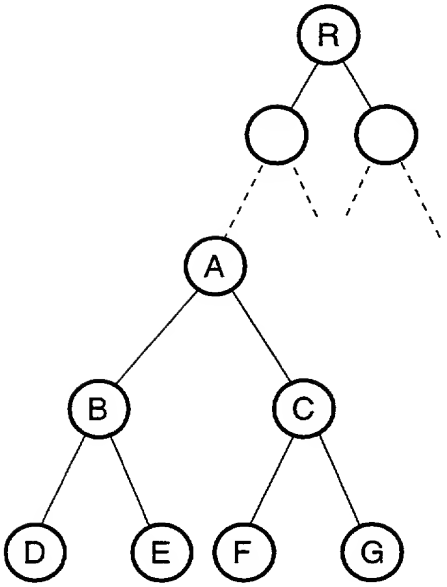



FIG.56

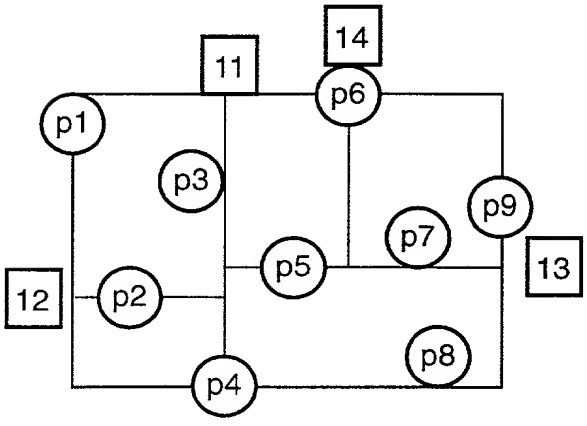


FIG.57

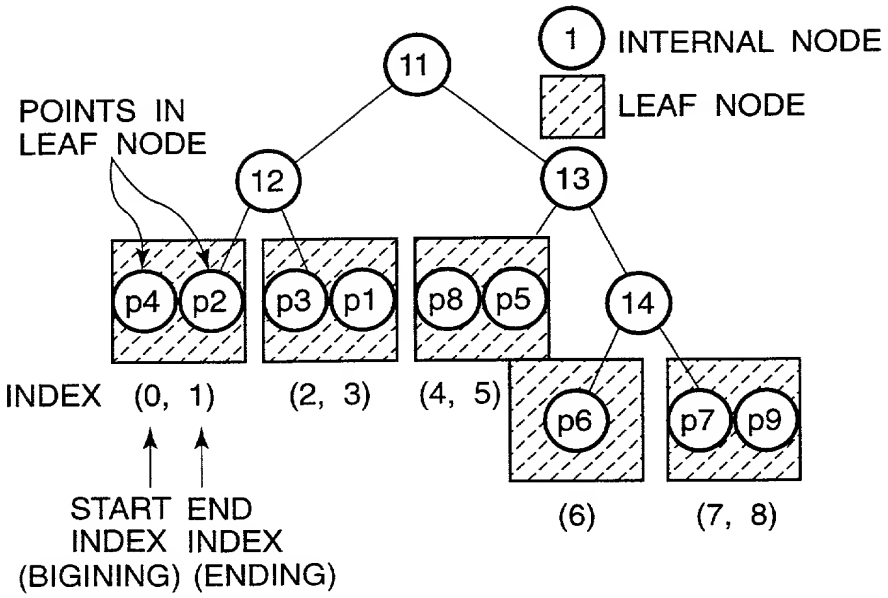



FIG.58

```
struck kdnode  {
    int        bucket;
    int        cutdim;
    float      cutval;
    kdnode     *loson,   *hison;
    int        lopt,   hipt;

};
```

FIG.59

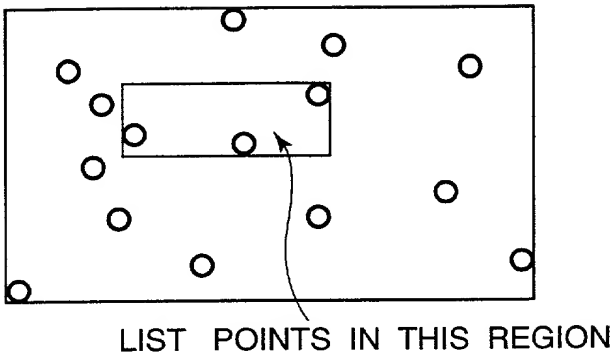



FIG.60

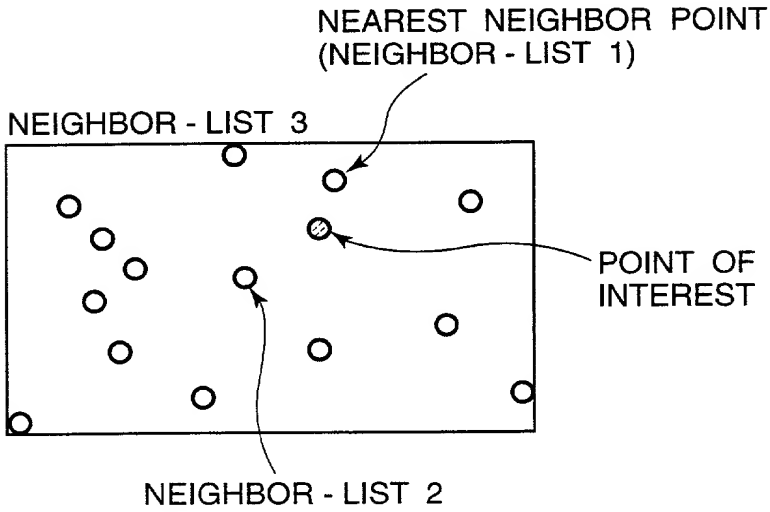



FIG.61

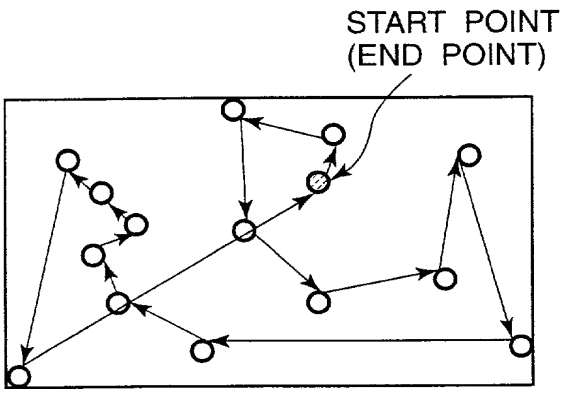


FIG.62

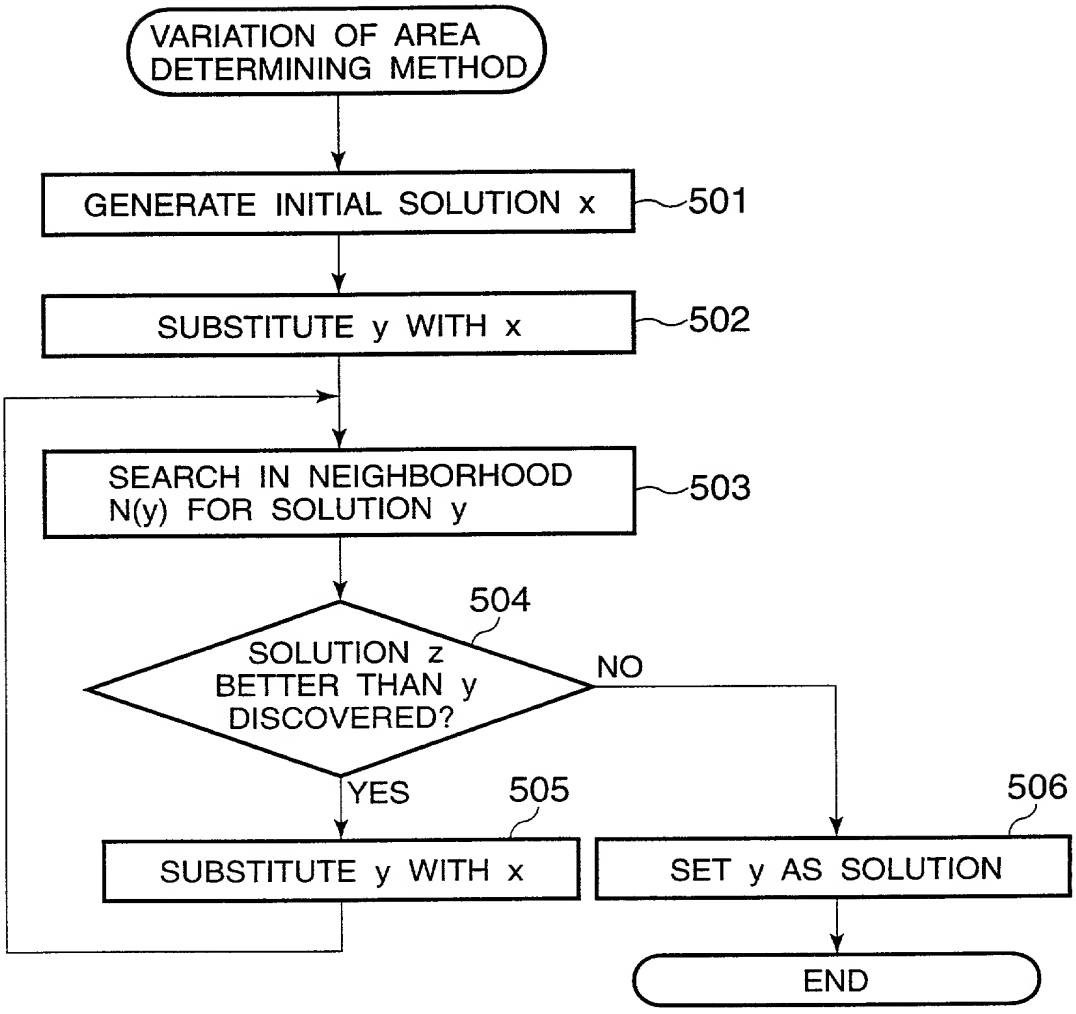

VARIATION OF AREA DETERMINING METHOD
GENERATE INITIAL SOLUTION x
501
SUBSTITUTE y WITH x
502
SEARCH IN NEIGHBORHOOD N(y) FOR SOLUTION y
503
504
SOLUTION z BETTER THAN y DISCOVERED?
NO
YES
505
506
SUBSTITUTE y WITH x
SET y AS SOLUTION
END

FIG.63

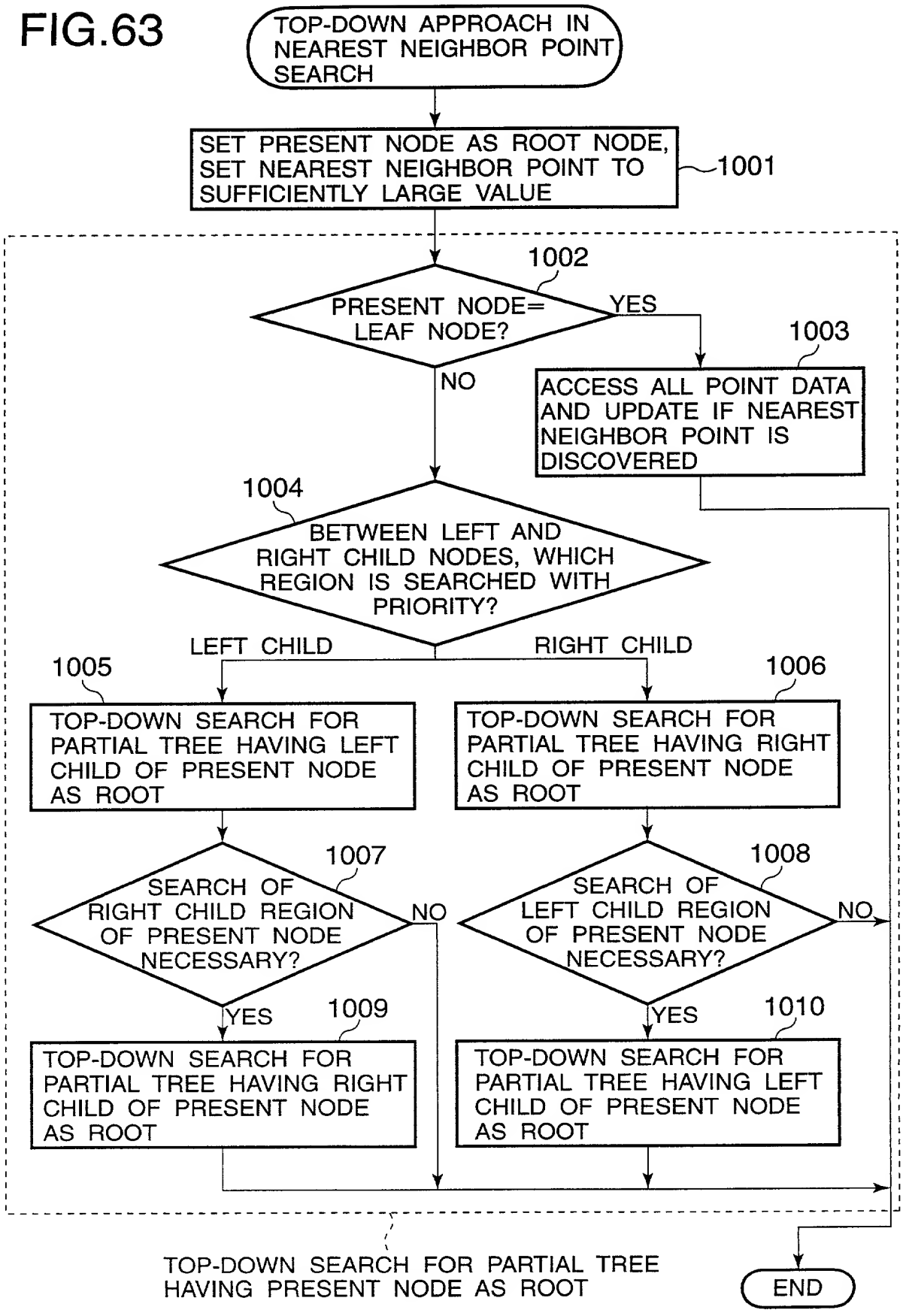

TOP-DOWN APPROACH IN NEAREST NEIGHBOR POINT SEARCH
SET PRESENT NODE AS ROOT NODE, SET NEAREST NEIGHBOR POINT TO SUFFICIENTLY LARGE VALUE
1001
1002
PRESENT NODE= LEAF NODE?
YES
NO
1003
ACCESS ALL POINT DATA AND UPDATE IF NEAREST NEIGHBOR POINT IS DISCOVERED
1004
BETWEEN LEFT AND RIGHT CHILD NODES, WHICH REGION IS SEARCHED WITH PRIORITY?
LEFT CHILD
RIGHT CHILD
1005
TOP-DOWN SEARCH FOR PARTIAL TREE HAVING LEFT CHILD OF PRESENT NODE AS ROOT
1006
TOP-DOWN SEARCH FOR PARTIAL TREE HAVING RIGHT CHILD OF PRESENT NODE AS ROOT
1007
SEARCH OF RIGHT CHILD REGION OF PRESENT NODE NECESSARY?
NO
YES
1008
SEARCH OF LEFT CHILD REGION OF PRESENT NODE NECESSARY?
NO
YES
1009
TOP-DOWN SEARCH FOR PARTIAL TREE HAVING RIGHT CHILD OF PRESENT NODE AS ROOT
1010
TOP-DOWN SEARCH FOR PARTIAL TREE HAVING LEFT CHILD OF PRESENT NODE AS ROOT
TOP-DOWN SEARCH FOR PARTIAL TREE HAVING PRESENT NODE AS ROOT
END

FIG.64

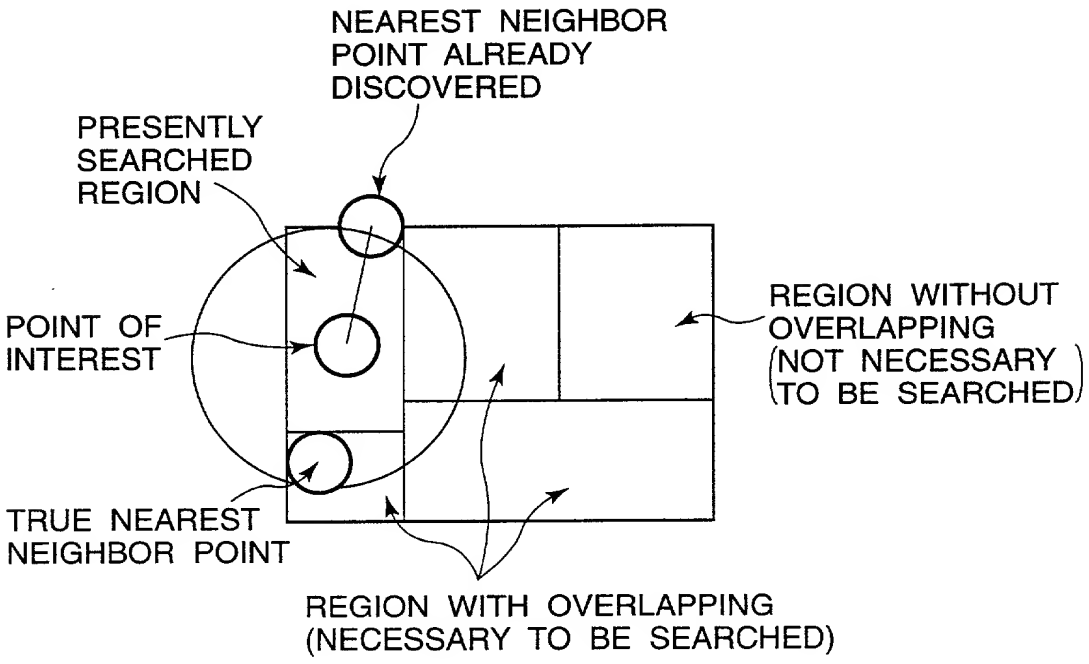

NEAREST NEIGHBOR POINT ALREADY DISCOVERED
PRESENTLY SEARCHED REGION
POINT OF INTEREST
REGION WITHOUT OVERLAPPING (NOT NECESSARY TO BE SEARCHED)
TRUE NEAREST NEIGHBOR POINT
REGION WITH OVERLAPPING (NECESSARY TO BE SEARCHED)

FIG.65

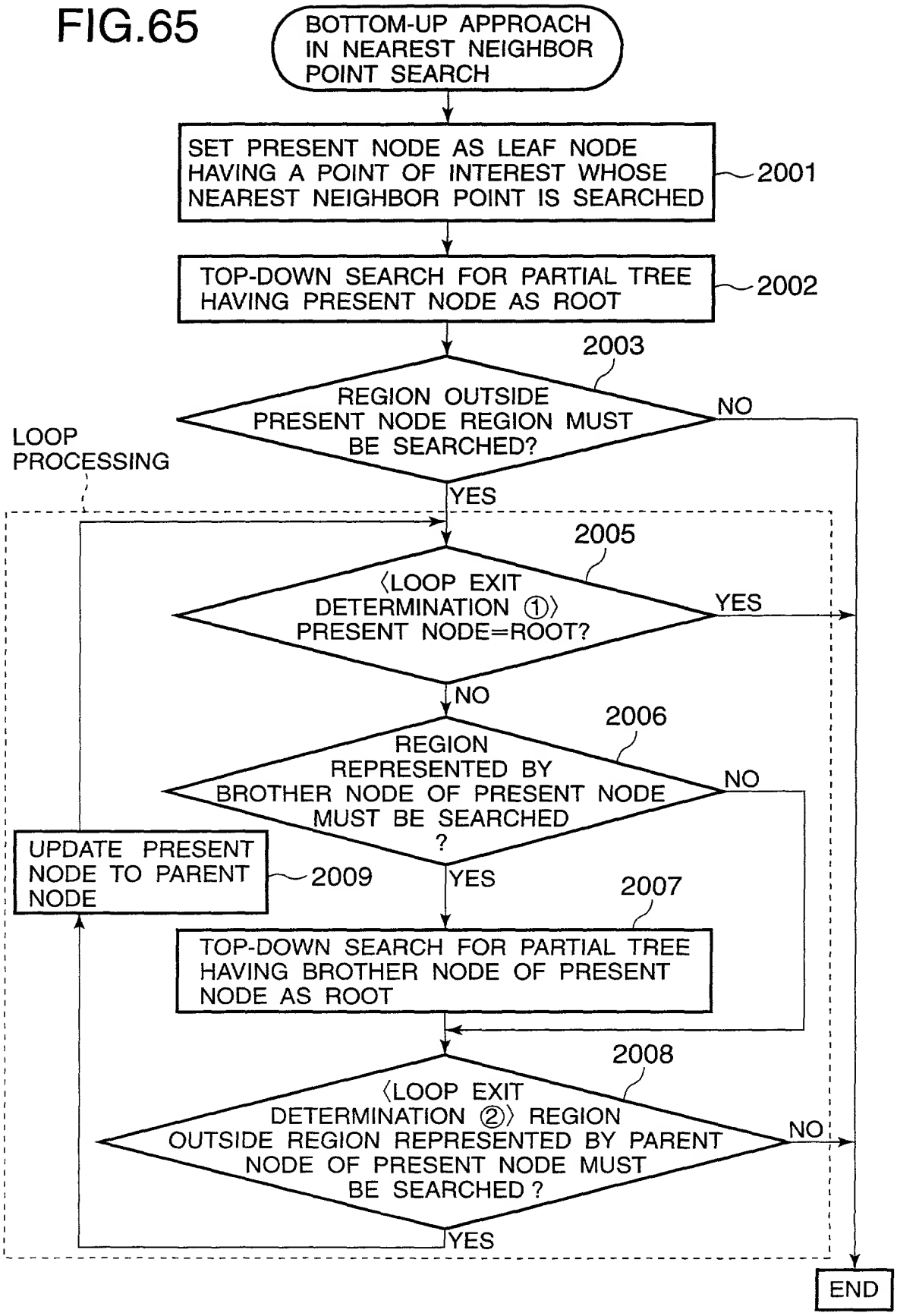

BOTTOM-UP APPROACH IN NEAREST NEIGHBOR POINT SEARCH
SET PRESENT NODE AS LEAF NODE HAVING A POINT OF INTEREST WHOSE NEAREST NEIGHBOR POINT IS SEARCHED
2001
TOP-DOWN SEARCH FOR PARTIAL TREE HAVING PRESENT NODE AS ROOT
2002
2003
REGION OUTSIDE PRESENT NODE REGION MUST BE SEARCHED?
NO
YES
LOOP PROCESSING
2005
〈LOOP EXIT DETERMINATION ①〉 PRESENT NODE=ROOT?
YES
NO
2006
REGION REPRESENTED BY BROTHER NODE OF PRESENT NODE MUST BE SEARCHED ?
NO
UPDATE PRESENT NODE TO PARENT NODE
2009
YES
2007
TOP-DOWN SEARCH FOR PARTIAL TREE HAVING BROTHER NODE OF PRESENT NODE AS ROOT
2008
〈LOOP EXIT DETERMINATION ②〉 REGION OUTSIDE REGION REPRESENTED BY PARENT NODE OF PRESENT NODE MUST BE SEARCHED ?
NO
YES
END

FIG.66


NEAREST NEIGHBOR
POINT IN REGION D
RADIUS=Q1−Q2 DISTANCE
TRUE
SHORTEST
DISTANCE
RADIUS=Q1−Q3 DISTANCE
POINT OF
INTEREST
Q2
Q4
Q1
Q3
A
B
C
D
E
F
G
H
I

FIG.67

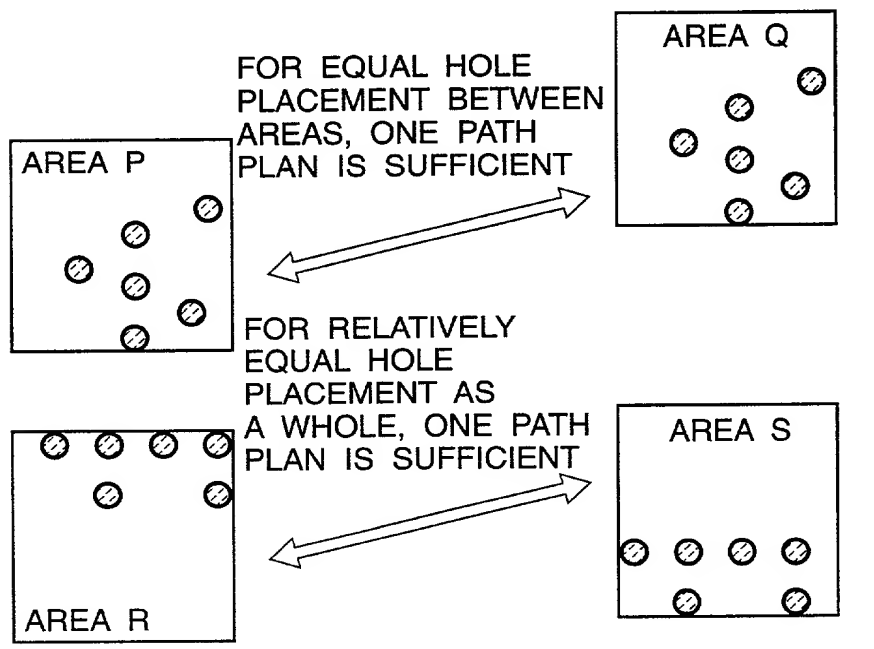

AREA Q
FOR EQUAL HOLE PLACEMENT BETWEEN AREAS, ONE PATH PLAN IS SUFFICIENT
AREA P
FOR RELATIVELY EQUAL HOLE PLACEMENT AS A WHOLE, ONE PATH PLAN IS SUFFICIENT
AREA S
AREA R

FIG.68

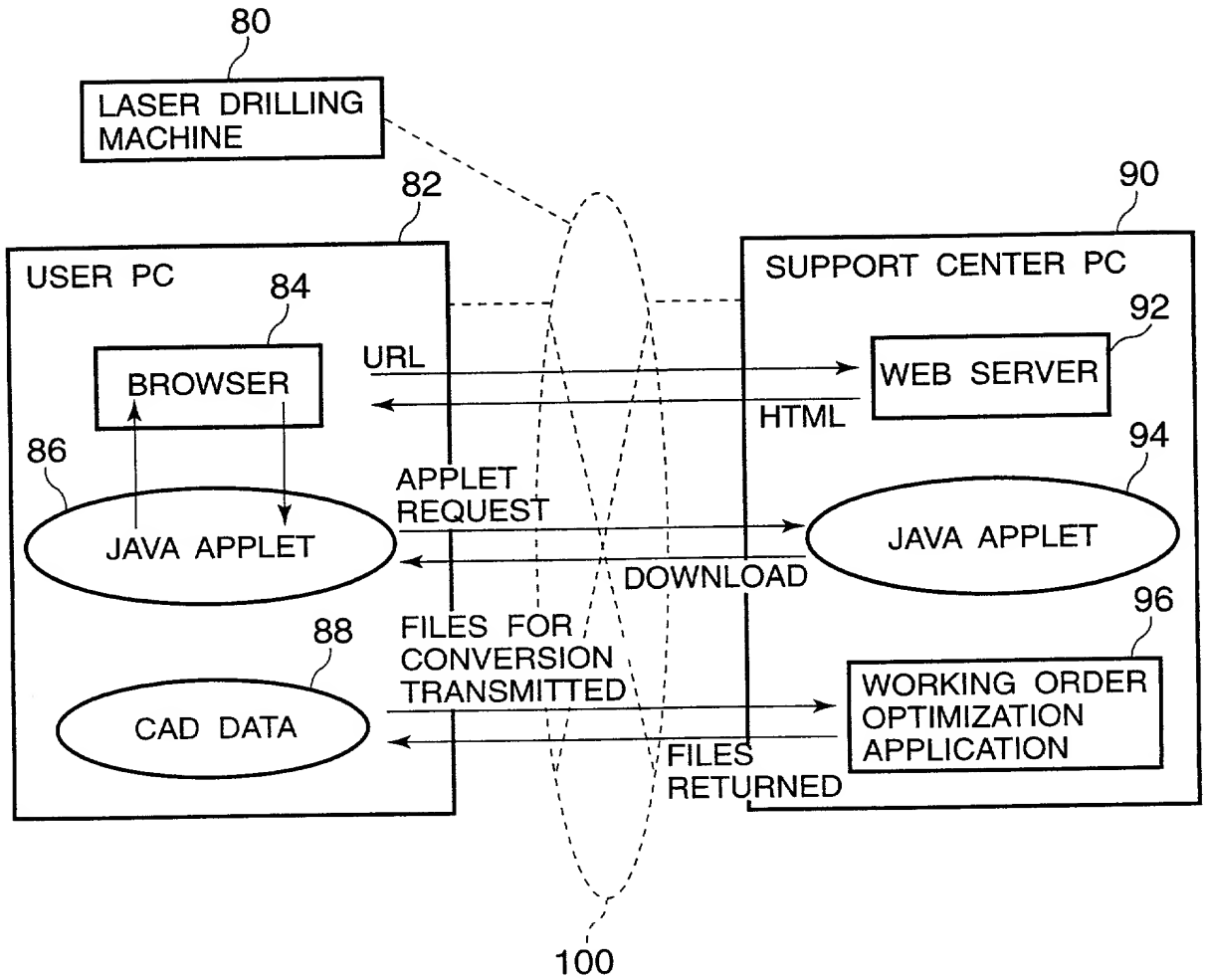

80
LASER DRILLING MACHINE
82
USER PC
84
BROWSER
86
JAVA APPLET
88
CAD DATA
90
SUPPORT CENTER PC
92
WEB SERVER
94
JAVA APPLET
96
WORKING ORDER OPTIMIZATION APPLICATION
URL
HTML
APPLET REQUEST
DOWNLOAD
FILES FOR CONVERSION TRANSMITTED
FILES RETURNED
100

FIG.69

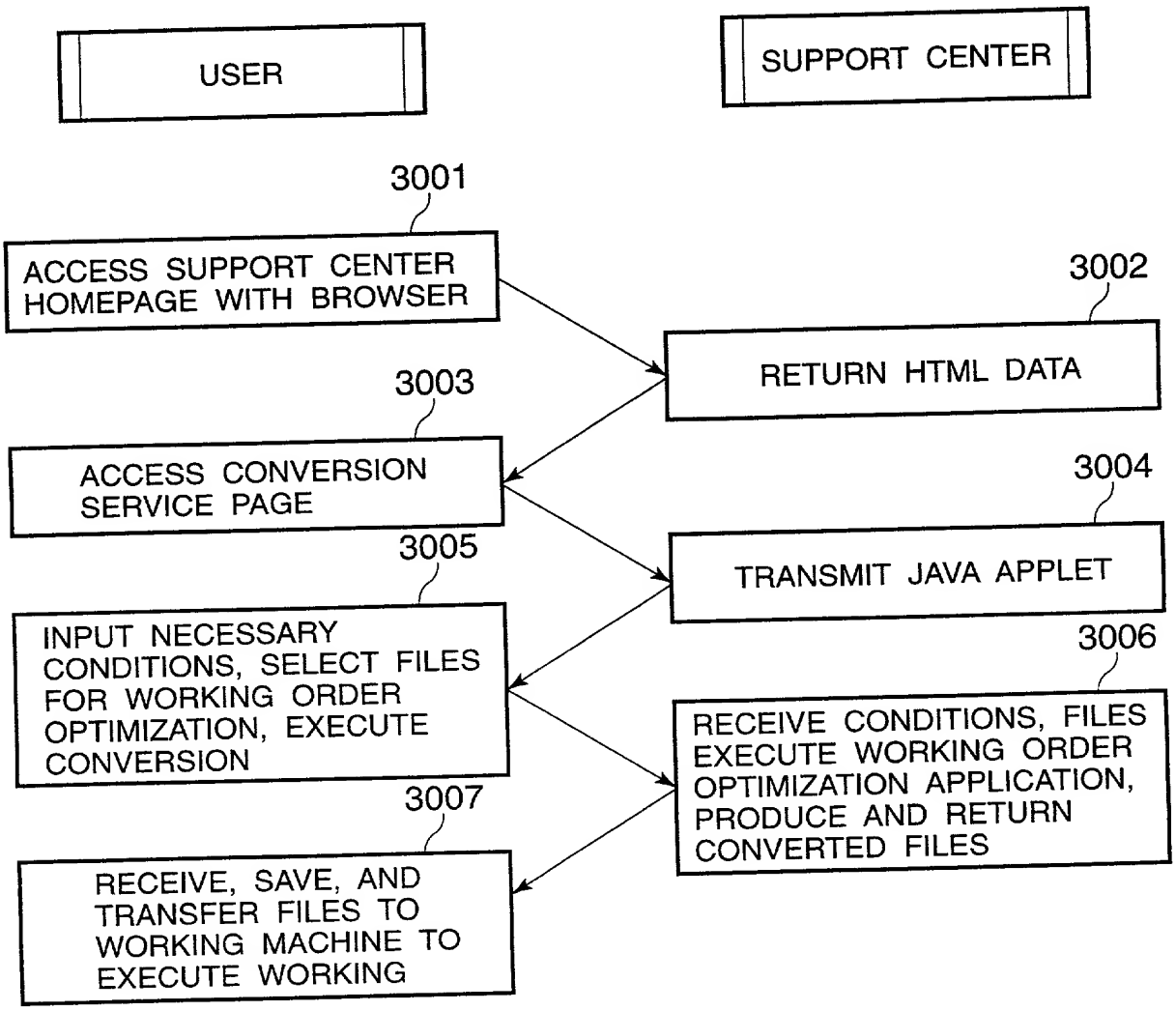

USER
SUPPORT CENTER
3001
ACCESS SUPPORT CENTER HOMEPAGE WITH BROWSER
3002
RETURN HTML DATA
3003
ACCESS CONVERSION SERVICE PAGE
3004
TRANSMIT JAVA APPLET
3005
INPUT NECESSARY CONDITIONS, SELECT FILES FOR WORKING ORDER OPTIMIZATION, EXECUTE CONVERSION
3006
RECEIVE CONDITIONS, FILES EXECUTE WORKING ORDER OPTIMIZATION APPLICATION, PRODUCE AND RETURN CONVERTED FILES
3007
RECEIVE, SAVE, AND TRANSFER FILES TO WORKING MACHINE TO EXECUTE WORKING

FIG.70

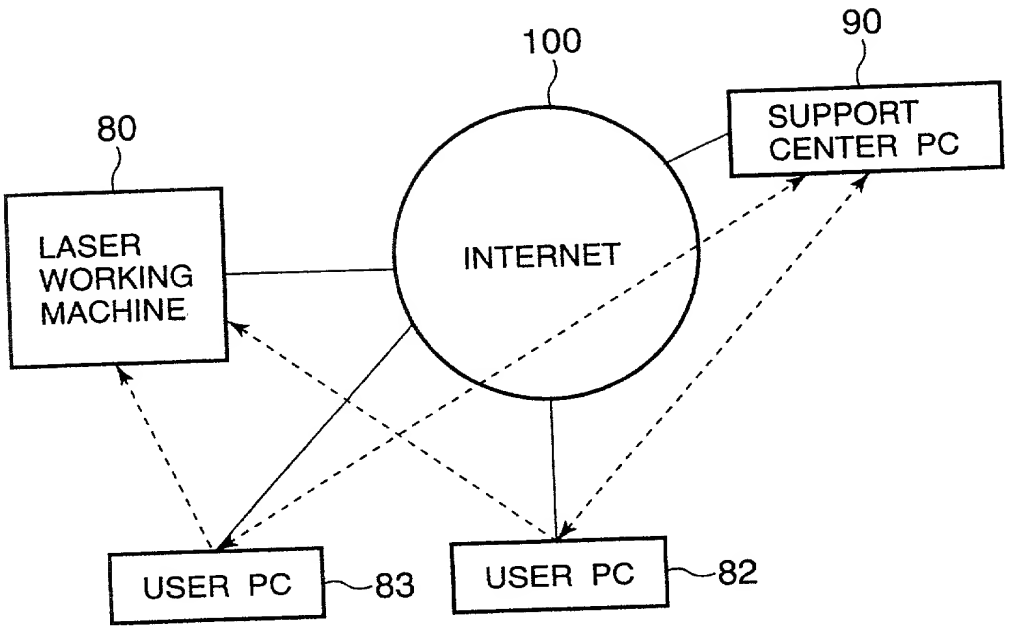

100
90
80
SUPPORT CENTER PC
LASER WORKING MACHINE
INTERNET
USER PC
83
USER PC
82

FIG.71

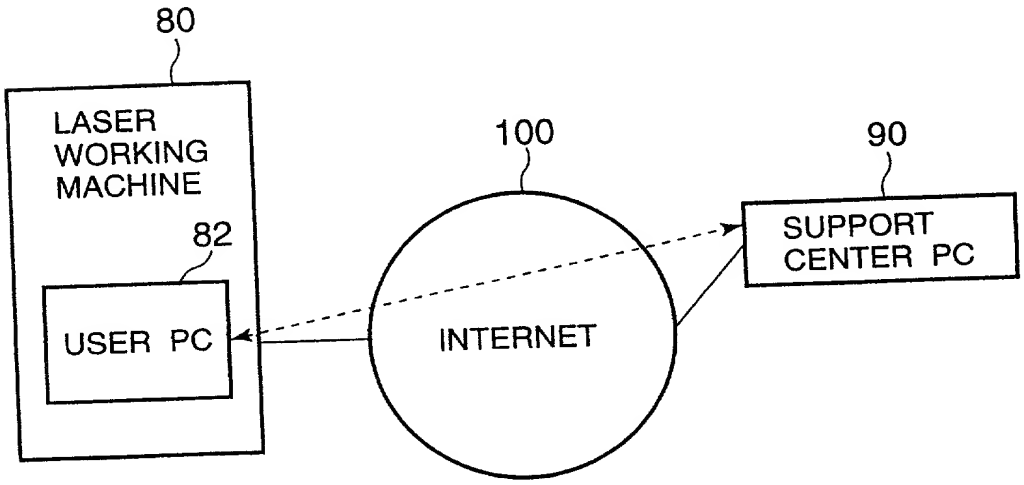
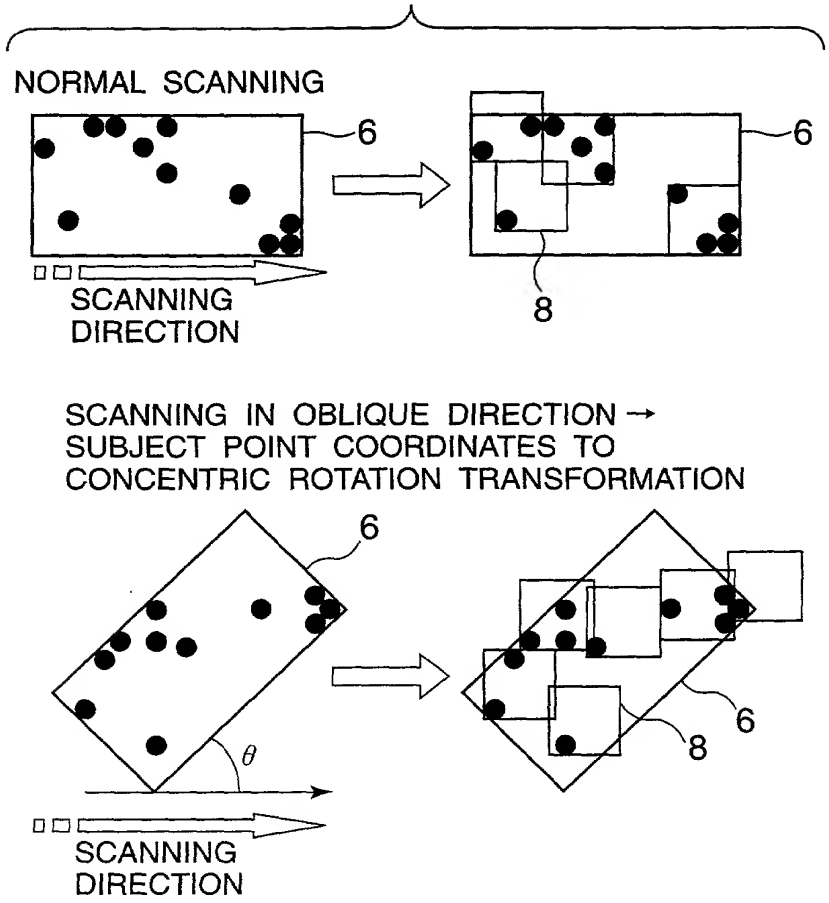

80
LASER WORKING MACHINE
82
USER PC
100
INTERNET
90
SUPPORT CENTER PC

FIG.72


NORMAL SCANNING
6
6
8
SCANNING
DIRECTION
SCANNING IN OBLIQUE DIRECTION →
SUBJECT POINT COORDINATES TO
CONCENTRIC ROTATION TRANSFORMATION
6
θ
6
8
SCANNING
DIRECTION